TRACTOR

REPAIR AND MAINTENANC

CIRCULAR 589

UNIVERSITY OF ILLINOIS • COLLEGE OF AGRICULTURE
Extension Service in Agriculture and Home Economics

CONTENTS

RULE 1 FOR TRACTOR SERVICE

Study your INSTRUCTION BOOK—do what it suggests. This circular does not replace it—it supplements it, as it deals with problems common to all tractors.

Your tractor will do its part if you do yours.

This Circular is a revision of No. 499 issued in 1939 under the same title.

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TRACTOR REPAIR AND MAINTENANCE

By R. I. Shawl, Chief in Farm Machinery

KNOWLEDGE and ability to repair and maintain a tractor and other power farming equipment are of utmost importance to the thousands of tractor owners who depend on this equipment to do most of their heavy drawbar and belt work. A tractor that has good care and is run a large number of days each year will do many more hours of work during its life than one that is operated intermittently and has poor care.

There are many ways to cut down on costly repairs. One way is to use only high-grade oils, greases, and fuels supplied from clean containers. Checking a tractor for repairs and adjustments each year, or at other regular intervals, catches all the loose bolts and nuts and the parts that need adjusting or replacing, a precaution that prevents serious delays in the field. *Every repair and adjustment should be taken care of just as soon as the need is found.*

On a general-purpose tractor operated under the supervision of the Department of Agricultural Engineering at the Illinois Experiment Station for 14,830 hours during the past eighteen years, repair costs, including some modernizing improvements, averaged 7.83 cents an hour (*Table 1*). After the first six years and again at the end of ten years some major repairs were necessary; but for the last eight years repairs were very moderate. A broken connecting rod in June, 1942, wrecked the engine and terminated the use of the tractor.

Tractors can be kept running until they become obsolete or the hour-cost of operation exceeds that of newer and better tractors. The average cost of operating the University tractor for eighteen years was 44.6 cents an hour.

Jobs for expert mechanic. Expert mechanics are needed to do some of the repair work on a tractor. This service is often available

Another helpful tractor publication, *Relief From Tractor Troubles* (Circular 574), will be sent on request. It consists of 16 pages and is a quick guide to checking, conditioning, adjusting, and preventive maintenance.

from the dealer, but if not, one should go to a reliable machine shop or garage. Some of the jobs for the expert are:

1. Fitting piston rings
2. Aligning pistons and rods
3. Refacing valves and seats
4. Scraping-in bearings
5. Checking the governor and engine speed
6. Overhauling the magneto and carburetor
7. Soldering fuel tanks
8. Overhauling transmission

Periodic inspection and repair. A general check list for the inspection and repair of a tractor is given on pages 6 and 7. Differences in the construction of tractors make it difficult to include all the parts to be checked and to state the time that should elapse between periods of inspection and repair. The parts to be checked and the frequency of checking suggested in this list should be compared with the directions in the tractor instruction book.

Before a tractor can be properly inspected, *it must be cleaned.* First wash it with water. Then take a paint brush and clean the tractor with kerosene or gasoline, using a putty knife to scrape off the thick grease. This operation may take half a day, but it is well worth while,

Table 1.—USE AND UPKEEP OF 18-YEAR-OLD GENERAL-PURPOSE TRACTOR

Year	Hours operated	Cost of repairs	Hours of labor for repairing		Hours of tractor chores[a]
			Farm	Expert	
1924-1925[b]	623	$ 13.10	20	3	79
1926	384	22.40	25	3	50
1927	161	40.00	30	5	9
1928	542	53.18	34	2	28
1929	875	53.75	41	16	43
1930	999	131.64	65	17.5	36
1931	760	114.70	76	8	33
1932	730	33.68	42	8	28
1933	855	101.57	49	10	36
1934	1 462	152.03	84	6	73
1935	1 074	64.50	84	9	29
1936	924	67.45	46	9	25
1937	1 073	65.37	39	4.5	26
1938	1 374	68.59	54	7	27
1939	1 008	41.00	45	16	20
1940	952	50.00	48	6	23
1941	765	46.63	22	4	19
1942	269[c]	42.30	42	3	6
Total	14 830	1 161.89[d]	846	137	590

[a]Tractor chores consist of greasing, changing oil, filling with water, fuel, and oil, and cleaning spark plugs. [b]Tractor secured in June, 1924. [c]A connecting rod broke June 6, 1942, wrecking the engine beyond repair. [d]Later models of this tractor should show lower repair bills.

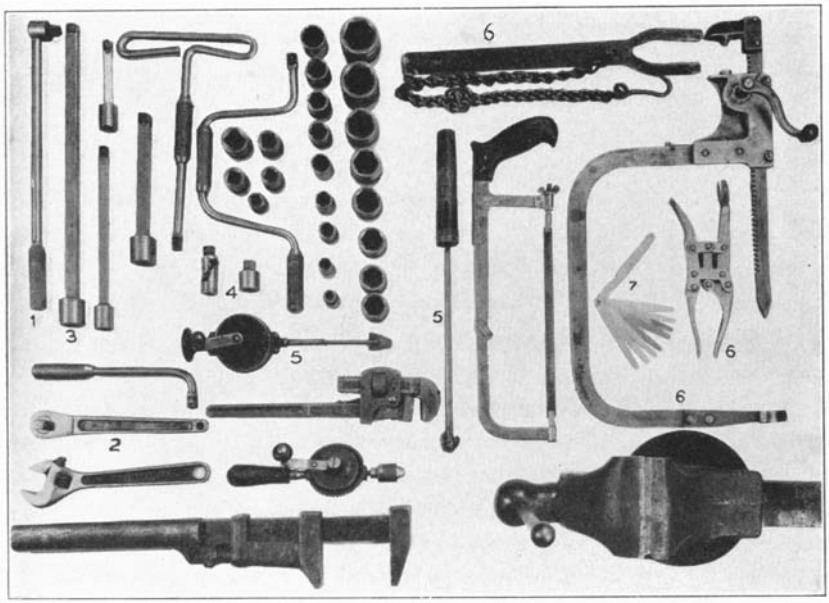

Fig. 1.—Special tools needed for tractor repair

The tools needed are not very expensive but they are very necessary. For some jobs it will be necessary to borrow the dealer's special tools or have him do the work. (1) Handle with jointed end, (2) ratchet handle, (3) large and small extensions, (4) adapter for large and small sockets, (5) two types of valve grinders, (6) three types of valve lifters for L-head and valve-in-head engines, (7) thickness gage.

for with a clean tractor all parts can be easily inspected and there is little danger of dirt falling into the crankcase or bearings when parts are removed. The importance of preventing dirt from entering the working parts of the tractor cannot be too strongly emphasized.

A coat of paint can be easily brushed on when the tractor is clean, which not only protects the tractor from rust, but gives the operator more pride and interest in the condition of the machine.

Delay in making needed repairs, large or small, is likely to be costly. The kind of care which an owner gives to the operation and maintenance of his tractor largely determines the service he will get from it.

REPAIR AND MAINTENANCE CHECK LIST

Part	When to check	What to do	See page
		Always consult the instruction book before making adjustments	
		ENGINE	
	hours	*In disassembling the engine, follow order listed below*	
Cylinder head	700-1,200	Remove carbon and grind valves if necessary	8
Valve wear	700-1,200	Check valve seat, valve face, and stem	8
Valve guides	700-1,200	Check the wear in valve guides	11
Valve grinding	700-1,200	Reface valve and seat if necessary, and grind	11
Valve clearance	400	Check valve clearance after grinding valves	16
Rocker arms	700-1,200	Examine for end-play and worn bushings	16
Pistons	700-1,200	Remove piston and connecting rod for inspection	16
Piston rings	700-1,200	Check ring wear on piston and in cylinder	18
Connecting rod	700-1,200	Inspect the bearings and take up play	20
Cylinders	700-1,200	Check for cylinder wear, scoring, and top ridge	19
Main bearings	700-1,200	Test crankshaft for looseness in bearings	23
Crankshaft	700-1,200	Test for scoring and out of round	24
Oil pan	700-1,200	Wash out the oil pan	24
Oil pump	700-1,200	Clean and inspect for wear	24
Oil screen	400- 800	Clean and inspect for holes—see instruction book	24
Oil filter	60- 120	Clean or change filter when oil is drained	25
Pressure gage	700-1,200	Inspect and check for pressure	26
Clutch	700-1,200	Inspect for wear in clutch and throw-out bearing	26
Engine support	700-1,200	See that engine is securely fastened	27
Governor	700-1,200	Inspect for wear and check engine speed	28
		FUEL SYSTEM AND CARBURETOR	
		Clean all lines and tanks; check for rust, wear, leaks	
Carburetor	700-1,200	Inspect needle valve and float chamber cut-off seats	29
Float	700-1,000	Check for condition and fuel level in carburetor bowl	30
Choke	300	See that choke works freely and opens completely	31
Butterfly valves	700-1,200	Check the wear around butterfly valve shaft	32
Air cleaner	300	Clean the top filter and soak in oil before replacing	32
Connections	20	See that connections for air cleaner are tight	35
Air breathers	10	Clean, soak in oil, and replace	35
		IGNITION	
		Inspect ignition system, but do not take system apart	
Breaker points	300-1,000	Check points for pitting and proper opening	37
Ground brush	1,500	Check the ground brush to the armature	40

REPAIR AND MAINTENANCE CHECK LIST *(Concluded)*

Part	When to check	What to do	See page
	hours		
Impulse starter	300	Clean and lubricate according to instructions	40
Distributor	300	Wipe carbon and dirt out of distributor cover	41
Dust seals	300	See that magneto dust seals are kept in good shape	43
Timing	1,500-2,000	Check for accurate ignition timing	43
Spark plugs	200	Clean and check gap at the points	44
Spark plug cables	700-1,200	Inspect the wires for breaks or rotted condition	46
		COOLING SYSTEM	
Radiator care	300	Flush system twice or more each year	49
Radiator cleaning	500-1,200	Clean the radiator with washing soda	49
Radiator scale	1,500-3,000	Remove scale when necessary	49
Hose	700-1,200	Keep tight and replace if not in good shape	49
Radiator curtain	700-1,200	Keep in shape for spring and fall use	50
Thermostat	700-1,200	Keep the cooling system and thermostat clean	50
Fan bearings	700-1,200	Check bearings—a wobbly fan may cause breakage	51
Fan belt	100	Tighten and inspect for wear	51
Fan pulley	700-1,200	See that fan pulley is keyed tight on the crankshaft	51
Water pump	100- 500	Check the packing and condition of the shaft	51
Antifreeze solution	10	Use the proper antifreeze solution	51
		FRONT WHEELS, AXLE, AND STEERING GEAR	
Front wheels	700-1,200	Wash and repack bearings; replace felt washers	53
Skid bands	700-1,200	Tighten bolts holding on skid bands	55
Front axles	700-1,200	See that axle works freely in frame	55
Tie rods	700-1,200	Wheels should have ½ to ¾ inch toe-in at the front	55
Axle brace	700-1,200	Tighten axle and allow free working rear connection	55
Steering gear	700-1,200	Take up play if possible and check lubrication	55
		REAR WHEELS, AXLES, AND TRANSMISSION	
Tires	60	Check air pressure, cuts, bruises, and worn spots	56
Rear wheels	200	Check bolts for tightness and inspect rubber tires	56
Rear axles	700-1,200	Check axle-play and replace felt washers as necessary	57
Transmission	1,000-2,000	Drain, wash with kerosene, refill with new oil	56
Belt pulley	700-1,200	Check bearings for wear	57
Brake	500-1,200	See that brake works properly	57
		CRAWLER TRACKS	
		Consult the instruction book for special directions on this type of equipment	

TRACTOR ENGINE

The engine, being the source of power for the tractor, needs frequent care and attention to keep it in first-class condition. Lack of compression because of bad valve conditions or worn or sticking piston rings is one of the chief causes of lack of power. After a season of farm work, which may be 300 hours or more, one should check the compression in each cylinder by cranking the engine slowly and noting the pull required for each cylinder. If a tractor operates 700 hours or more a year, it is usually desirable to remove the cylinder head so that the carbon can be scraped off and the valves inspected.

When removing the cylinder head, it is sometimes difficult to break it loose after all the nuts and bolts are removed. The best way to loosen the head is to turn the engine crank and let the compression loosen it; then clean all carbon from the cylinder head and pistons. It is not good

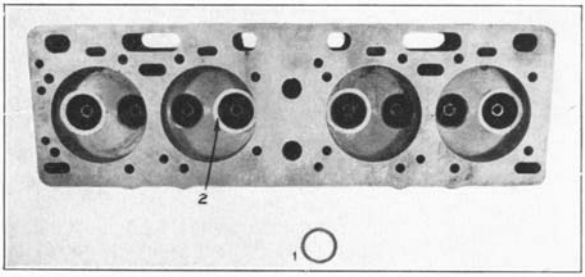

Fig. 2.—Cylinder head with valve insert seats for exhaust valves
(1) Valve insert seat, (2) seat in place.

practice to use a cylinder-head gasket a second time unless a new one cannot be obtained. When installing a new cylinder-head gasket, soak it in water for at least 10 minutes and apply some grease to both surfaces of the gasket before assembling the engine.

Valve wear usually occurs on the valve face and on the stem where it enters the valve guide. Before removing the valves for inspection, number them starting valve No. 1 at the crank end of the engine. If the valve faces are badly pitted and cannot be reconditioned by grinding, or if grooves are worn in the valve faces, reface them in a valve-refacing machine. The edge of the valve should be blunt (*Fig. 3*). If in refacing it becomes sharp, the valve must be replaced with a new one. A sharp edge burns rapidly and destroys the fit of the valve. If new rings are not installed when the valves are ground, the engine may pump oil.

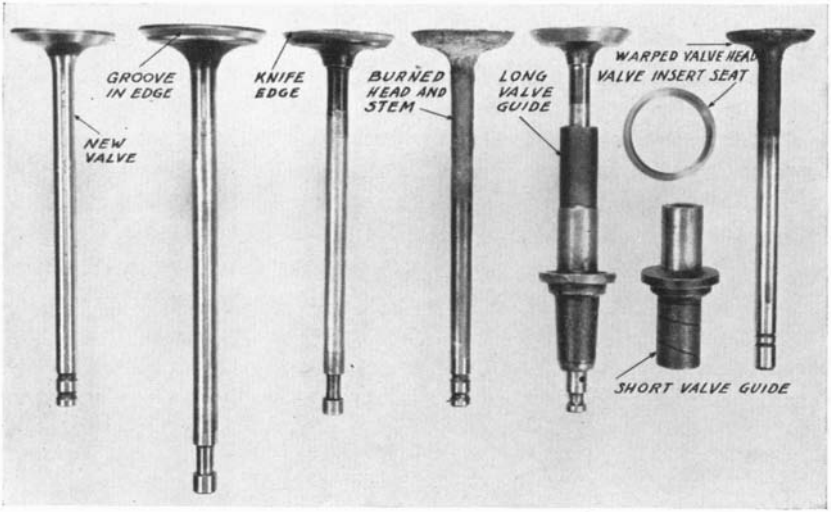

Fig. 3.—Valve troubles that must be corrected

Valves with grooved or pitted edges must be refaced. Valves with sharp upper edges or warped heads must be replaced. Long guides cause valves to stick and should be cut off flush with the port. Worn guides prevent proper valve seating.

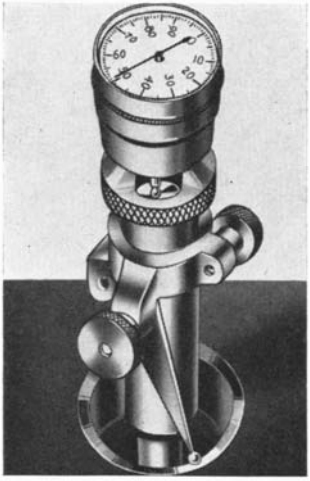

Fig. 4.—Gage for valve seats

For a perfect fit, valve seats must be checked with a gage.

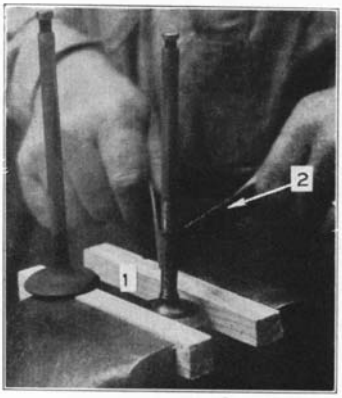

Fig. 5.—Polishing a valve stem

(1) Block of wood, (2) strip of fine emery cloth.

Many tractor owners feel that grinding valves is a job best done by an implement dealer whose special equipment, such as refacers, reamers, and seat gages (*Fig. 4*), enables him to secure a perfect fit.

If the valve seat is in such bad condition that it cannot be restored by grinding, it can be refaced with reamers. If reaming leaves the seat too wide, it must be reamed down on top and off at the bottom. The reaming must usually be done by an expert mechanic and may not be an entirely satisfactory method of making repairs. A better method of repairing the exhaust-valve seat is to have a mechanic from a machine shop or a garage put in new alloy valve-seat inserts (*Figs. 2 and 3*). These inserts do not burn or pit readily, and therefore give excellent service. The installation is moderate in cost and can be done at the farm by a garage mechanic. When insert valve seats have been installed, take care to prevent the motor's overheating from lack of water or other causes or the seats may be loosened.

Carbon burns on the valve stems just under the valve head and causes the stem to become rough. The rough stem pushing into the valve guide, and abrasives working down into the valve guide cause rapid wear, preventing the valve from seating properly. Clean and polish the valve stems and inspect the valve guides (*Fig. 5*).

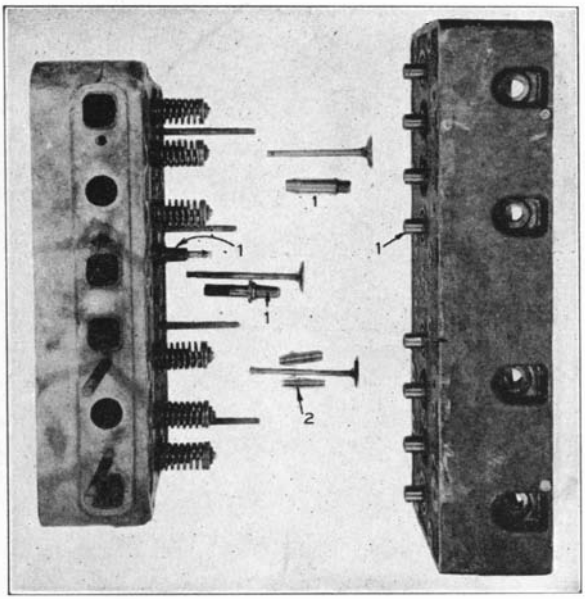

Fig. 6.—Cylinder heads showing valve guides

(1) Types of removable one-piece valve guides, (2) split valve guide.

Badly worn valve guides do not allow the valve to seat properly. Such guides should be driven out with a piece of wood or soft metal and new ones installed (*Figs. 3 and 6*). The seat should then be trued up with the valve guides by means of a valve-seat reamer. When new valve guides are installed, it is usually best to put in new valves. If the guide is badly worn and is not replaceable, ream the hole larger and use a valve with an oversized stem.

Grinding valves is a difficult job and requires time and patience. After the valve has been removed and cleaned, and the face and seat prepared, as directed under the section on *valve wear,* it is ground to an air-tight fit on the seat by means of a suitable valve-grinding com-

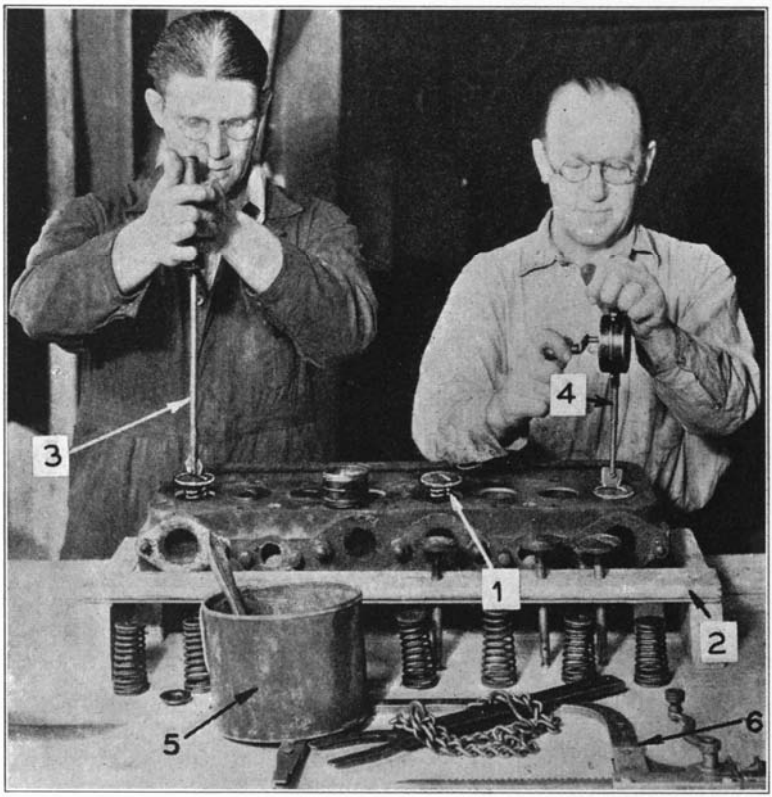

Fig. 7.—Grinding valves

(1) Light spring to raise valve for turning, (2) board with holes for holding valves, (3) screw driver type of valve grinder, (4) oscillating type of valve grinder, (5) cup for washing grinding compound from valves, (6) valve lifters.

pound. There are two commonly used types of *valve-grinding compound* on the market:

1. An abrasive mixed with oil to form a sort of paste. This compound, which is widely used, is put up in small cans containing coarse compound in one end and fine compound in the other end.

2. A water-mixed compound. This is much finer than the oil-mixed and usually grinds faster. PRECAUTION: The water in this compound causes rapid rusting and sticking of the valve parts. After grinding the valves, remove all of the moisture, dry the parts, and apply a coat of oil. Follow this precaution very carefully. Operate the motor as soon as possible after using the water-mixed compound.

The *coarse-grinding compound* (mentioned in **1** above) is designed only for removing the pits on badly pitted valve seats. After the pits are removed, the valve is ground with the fine compound. First coat the valve face with a thin layer of grinding compound and then place the valve back on its seat, using a light coil spring over the valve stem to help lift the valve while grinding it (*Fig. 7*). Next turn the valve back and forth about half way a number of times and allow the spring to lift it up; then give it a half turn and grind it some more. Apply very light pressure and never turn the valve continuously in one direction, for continuous turning in one direction causes grooves to appear on the surface. Any one of the following tools can be used to turn the valves while they are being ground: oscillating grinder, small hand drill with screw driver blade, or a screw driver (*Fig. 1*). A carpenter's brace is too heavy and clumsy for this work.

When the compound ceases to grind, wipe it off and apply a new coat. Continue grinding the valve until a smooth gray band, the width of the valve seat, which should be from 3/32 inch to 5/32 inch, shows all the way around the valve. This band should have a distinct edge, both at top and at bottom. When all the pits and grooves are removed, the job is finished. Clean all grinding compound from the valve and seat, oil the valve and stem, and assemble the parts.

Valve sticking in tractor engines is a source of much trouble on many Illinois farms. A large part of this trouble could be avoided if the operator would take time to give engine and valves proper care.

A sticking valve can usually be remedied by removing the spark plug of an L-head engine and squirting some kerosene on the valve, or by removing the valve cover of a valve-in-head engine and squirting kerosene on the valve stem. This, however, often does not get at the cause back of the sticking. A number of suggestions for preventing sticking are listed below. The simplest should be tried first.

1. Lubricate the valves. Adequate lubrication of the valves is highly

important. If they are not lubricated by a force-feed system, a liberal supply of crankcase oil should be applied to them from an oil can at least twice a day. The valves of some tractor engines are lubricated by means of a valve-cover breather. The air from the cooling fan blowing past the breather draws oil vapors from the crankcase up past the valve stems. Too heavy an oil in the crankcase will not give off sufficient vapor to lubricate the valves. When a tractor is to stand idle for a considerable period, the valve cover should be removed if possible and a liberal supply of oil applied to the valves, after which the cover should be tightly replaced.

2. Use clean cistern water in the cooling system. If hard water is used, give the radiator an acid cleaning treatment as suggested on page 49 at least once every two years. Lime from hard water may collect on the inside of the cooling system (*Fig. 41*) in sufficient quantity to retard the flow of heat from the combustion chamber to the cooling water. A film of lime only 1/32 of an inch thick may cause the engine to overheat. This excess heat in the cylinder often causes the valve stems to become dry and to stick.

3. Use spark plugs with a heat range suited to engine temperature and fuel. The wrong type of spark plug is likely to cause faulty operation of the engine and valves and rapid deterioration of the plugs (*see page 45*).

4. See that lower ends of valve-stem guides have not become thickened. These guides, extending down thru the cylinder head into the manifold chamber, sometimes become very hot, especially at the end extending into the exhaust chamber, and collect carbon and other material from the combustion chamber, causing the end to become thickened and the opening smaller. This thickening, or "grain growth" as it is sometimes called, may cause overheating or scratching of the valve stems, making them stick. Reaming out the lower end of the valve guide, making the opening 1/32 of an inch larger extending back half an inch from the end, may leave enough clearance for the proper operation of the valve. Some operators cut off the end of the valve guide extending into the cylinder, cutting it flush with the inside of the combustion chamber, in order to prevent this part from heating and causing the valves to stick (*Fig. 3*).

5. Remove gum deposits from valve stems. Gum from gasoline sometimes collects on the valve stems and causes sticking. Kerosene or one of the special gum solvents can be used to remove this gum. To remove the gum from the engine parts, many farmers add 2 or 3 gallons of kerosene (*not* distillate or other low-grade fuels) to a tank of gasoline every 150 to 200 hours or oftener.

6. Maintain proper valve tappet clearance. This is necessary in order to give correct valve timing and prevent the valves from being held off their seats. Being held off their seats causes valves to burn.

7. Provide additional lubrication of valve stems, if necessary, in one of two ways: (1) By countersinking a hole in upper end of valve guide to a depth of 3/8 inch, using a metal drill somewhat larger than the valve stem. This will form a pocket in which oil may collect around the valve stem. (2) If the valve guide is replaceable, by drilling small holes 5/32 inch in diameter at three places around the valve guide (*continued on page 16*)

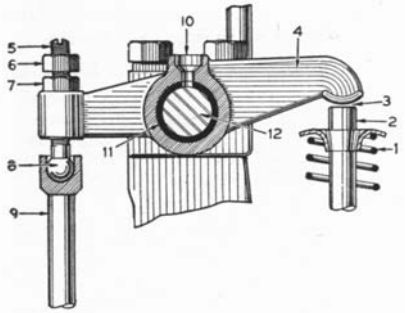

Fig. 8.—Detailed view of overhead valve and rocker-arm clearance adjustment

(1) Valve spring, (2) valve stem, (3) valve clearance, (4) rocker arm, (5) rocker-arm adjusting bolt, (6 and 7) lock nuts, (8) ball-and-socket joint, (9) push rod, (10) oil hole, (11) removable bronze bushing, (12) rocker-arm shaft.

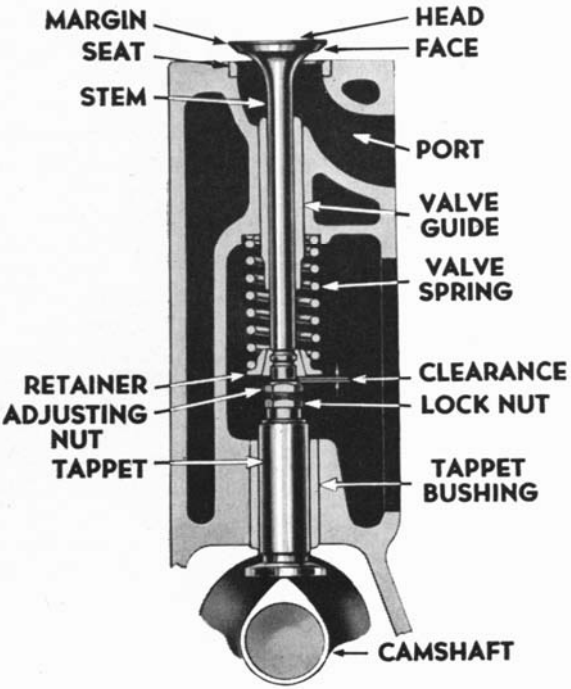

Fig. 9.—Detailed view of L-head valve assembly

L-head valves are somewhat difficult to adjust because they are hard to get at. They are seldom used on tractor engines.

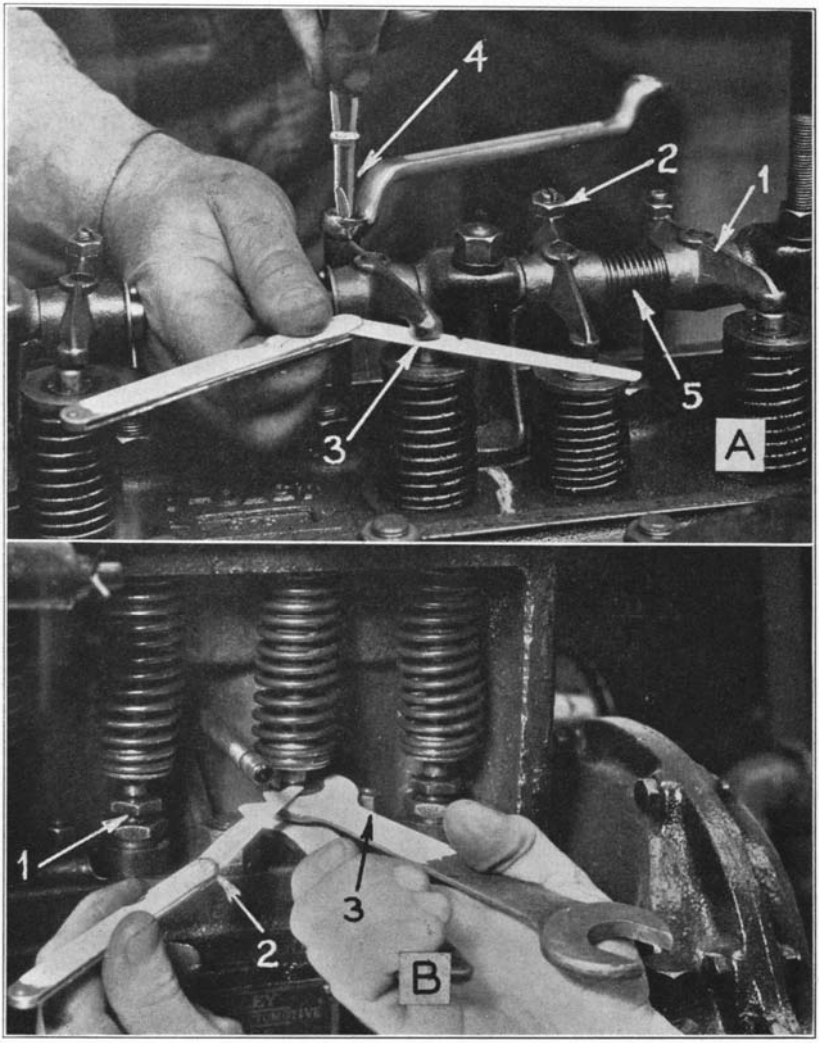

Fig. 10.—Adjusting valve clearance

A. Valve-in-head engine: (1) rocker arm, (2) lock nut and slotted adjusting stud, (3) thickness gage, (4) wrench and screw driver for loosening and turning, (5) spring to keep rocker arms centered over valves.

B. L-head engine: (1) adjusting stud and lock nut, (2) thickness gage, (3) special wrenches.

just above the cylinder head. The downward slanting holes will allow the oil running down the valve springs to drain down around the valve stem.

8. Check for improper seating of valves. If the valves are not properly seated, the hot exhaust gases blowing by them will cause them to burn and stick.

9. Have tension of used valve springs checked with that of new springs. Weak valve springs may not close the valves quickly and tightly.

Valve clearance (which is the distance left between the end of the valve stem and the valve lifter or rocker arm to allow for the expansion of the heated parts) must be readjusted after the valves are ground (*Figs. 6 and 9*).

After the engine has been assembled, give the valves a little extra clearance and run the engine for an hour or so to warm it up thoroly. This expands the engine parts and cylinder-head bolts, so that the head can be securely tightened down, which is absolutely necessary in a valve-in-head engine before the valves are adjusted. With the engine warmed up, adjust the valves, using a thickness gage (*Fig. 10*). This operation must be carefully done. Crank the engine until the valve to be adjusted closes; then to be sure that the cam has moved away from the push rod or valve lifter, give the crank another quarter turn. Loosen the lock nut on the push rod or valve lifter and, using the thickness gage, adjust the clearance at the end of the valve stem to the number of thousandths of an inch specified in the instruction book. The gage must bind slightly when pushed under the valve stem. Take up all the slack from the push rod and rocker arm when this measurement is made. This valve clearance runs from .007 to .040 inch in a valve-in-head engine and from .006 to .012 inch in an L-head engine.

After adjusting the valve clearance, run the engine a few days and then recheck the clearance.

Special wrenches for adjusting the valves are usually supplied with an L-head engine. Valves that do not have enough clearance fail to close tightly, leaving a space which allows the hot gases to blow by the valves, causing burning, warping, and loss of power.

Rocker arms have very little play on the shaft and are held in place by springs or locks, so that they center over the end of the valve stem. Some motors have bushings in the rocker arms that need to be replaced when worn (*Figs. 8 and 10-A*).

Pistons and connecting rods should be removed, cleaned, and inspected every 700 to 1,200 hours. Remove piston rings as shown in Fig. 11-A. Oil splashing up against the underside of the hot piston head burns and forms carbon, which must be scraped off or it will

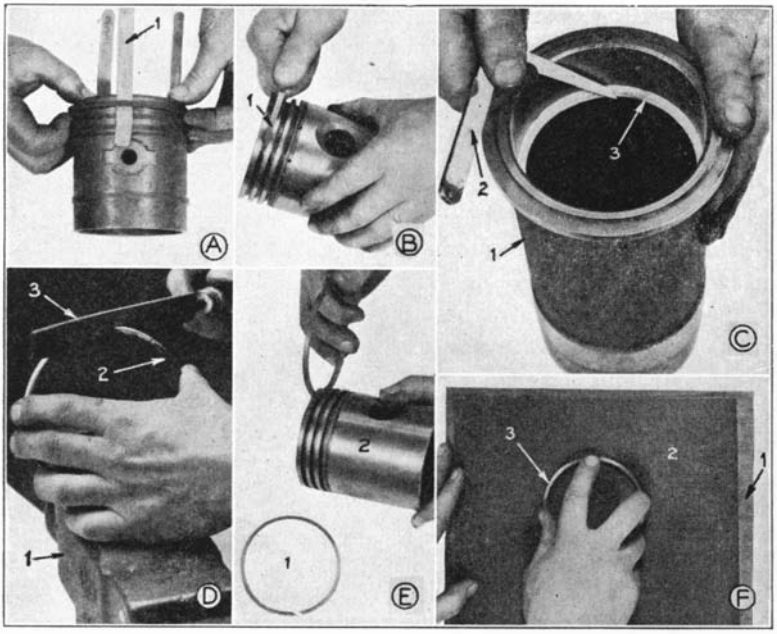

Fig. 11.—Fitting piston rings

A. Removing piston rings: (1) with metal strips.

B. Cleaning ring grooves: (1) with broken piston ring.

C. Measuring piston-ring clearance in cylinder: (1) replaceable cylinder sleeve, (2) thickness gage, (3) piston ring pushed down two-thirds way in cylinder.

D. Filing piston-ring ends to secure proper clearance in cylinder: (1) vise, (2) piston ring held lightly in vise, (3) sharp flat file.

E. Fitting piston ring to piston-ring groove: (1) new piston ring, (2) rolling ring around groove.

F. Dressing down width of piston ring: (1) board, (2) fine emery cloth, (3) piston ring.

accumulate in sufficient quantity to break loose and drop into the crankcase. Carbon on the underside of the piston causes the piston to run hotter. Clean the piston-ring grooves with a screw driver or a piece of broken piston ring, being very careful not to scratch the sides of the groove (*Fig. 11-B*). Scratching the sides of the groove may cause the rings to stick when the engine becomes hot and prevent their proper functioning.

The piston and the cylinder should be checked for wear. This is done by inserting a long-bladed feeler gage alongside the skirt or bot-

tom of the piston when in its natural place in the cylinder. The clearance should be checked at the side and front of the cylinder. In new tractors the total clearance between the skirt, or bottom, of the cast-iron piston and the cylinder wall will run from .004 to .005 inch. If the engine has worn so that this clearance exceeds .012 inch, the cylinders should be reconditioned by honing, boring, or grinding, or else by replacing new sleeves, and then installing new pistons.

Piston rings after being removed, as discussed under *pistons,* should be cleaned and checked for side wear in their grooves and for gap clearance in the cylinder. The top ring will usually show considerable wear, especially if a low-grade fuel is used. Put each ring in the proper cylinder and with the piston push the ring more than half-way down so that the ring will be placed squarely in the cylinder (*Fig. 11-C*). Measure the gap or end clearance with a thickness gage. If new oversized rings are used, adjust the ring gap clearance by filing (*Fig. 11-D*) as follows:

1. **In small-bore engines** allow at least .007 inch for the ring gap clearance.

2. **For top piston ring gap,** allow .003 inch clearance for each inch of cylinder diameter. In some engines all rings are fitted with .003-inch clearance.

3. **For next ring gap,** allow .0025 to .003 inch for each inch of cylinder diameter.

4. **The bottom ring and oil ring** can be fitted with .002 inch for each inch of cylinder diameter if a closer fit than that given in **3** is desired, provided the total gap is not less than .007 inch.

If standard-sized piston rings are too small, rings with oversized diameters, starting with .005-inch oversize or larger, can be used. Some tractor manufacturers do not make oversized rings because they feel that when the cylinder is so worn that standard sized rings will not fit, the cylinders should be replaced. If a cylinder takes more than a .015-inch oversized ring, it is usually in need of reconditioning. If oil pumping cannot be stopped with new piston rings, the cylinders usually must be replaced or reconditioned.

If the gap exceeds to any extent the limits given above, install new rings, provided that not more than .008 to .010 inch wear has taken place in the cylinders. If the wear exceeds this limit, it is probably best to recondition the cylinders or put in new sleeves. Rings with straight-cut joints are most commonly used and make it easier to measure the clearance than where diagonal or step joints are used. In fitting new piston rings, proceed carefully as follows:

1. Fit ring to piston groove as shown in Fig. 11-E. If ring is too tight, dress it down in width until it moves freely in the groove. The ring can be dressed by rubbing it on a sheet of fine emery paper placed on a smooth surface (*Fig. 11-F*).

2. Check ring in cylinder for proper gap clearance, as previously described (*Fig. 11-C*). Do this part of the work very carefully.

3. Assemble rings on pistons, using the three metal strips, as shown in Fig. 11-A. When the rings are fitted with different gap clearances, put the ring with the most clearance in the top groove.

Cylinders become worn from improper lubrication, cold or hot spots on cylinder wall, operating engine cold (below 140° F.), corrosion from combustion, abrasives in the crankcase, and dirt coming in thru the carburetor. Eliminate all of these causes as far as possible. Piston rings rubbing the cylinder walls cause wear, and on engines that have been used a long time there is likely to be a ridge left at the top of the cylinder just above the top piston ring. When new rings are installed, remove this ridge with a suitable reamer to prevent the rings being broken by striking it. In engines equipped with replaceable cylinder sleeves, cylinder wear can be easily repaired by putting in a new assembly of sleeves, pistons, rings, pins, and bushings (*Fig. 12*). Re-

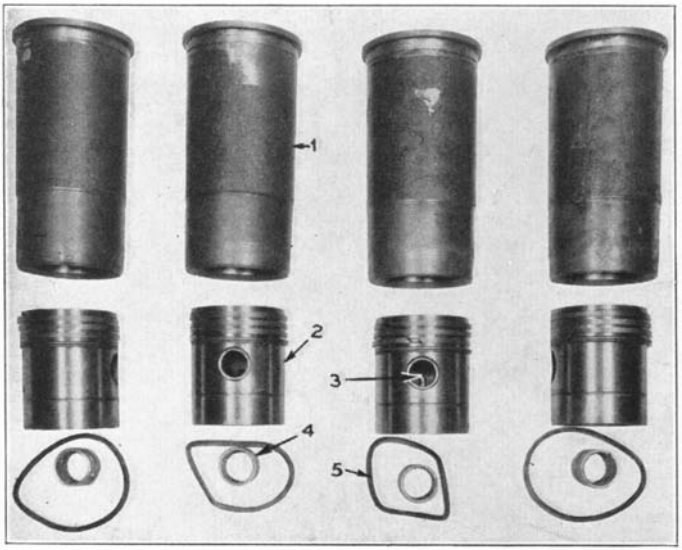

Fig. 12.—Set of replaceable cylinder sleeves or liners with pistons fitted to sleeves

(1) Sleeve, (2) piston complete, (3) piston pin, (4) piston-pin bushing, (5) rubber gasket for sealing bottom of sleeve to prevent water leakage into crankcase.

placeable sleeves are usually the wet type, but recently some manufacturers have changed to the dry sleeve, which is a thin sleeve inside the regular cylinder, to prevent leakage of water into the crankcase. In other types of engines the cylinders must be bored, ground, or honed. Some machine shops are equipped to bore or hone the cylinders at the farm, but the cylinder block must be taken to the shop to be ground. The method of reconditioning the cylinder will depend largely upon the circumstances under which the work is to be done and their effect upon the cost.

Connecting rods may have bearing surfaces at both the top and the bottom (*Figs. 13 and 14*). Wear in the bronze bushing at the top of the connecting rod can be detected by a tapping sound while the motor is running or by looseness when the piston and rod assembly are removed and inspected. This looseness can be corrected by putting in a new piston pin and bushing or an oversized piston pin. Usually the first method is employed. This replacement, which is difficult to make on the farm because of the accuracy of workmanship required, should

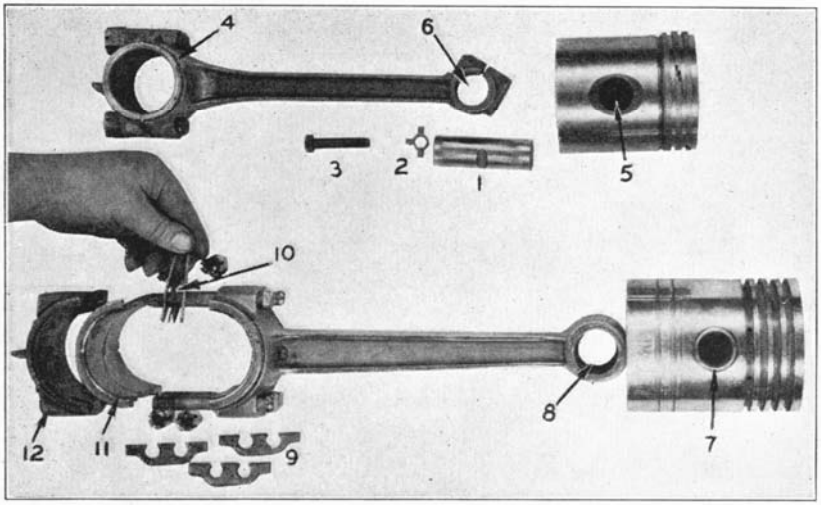

Fig. 13.—Older type of piston and connecting-rod assemblies

(1) Piston pin, (2) lock washer for bolt, (3) bolt for securing piston pin in end of connecting rod, (4) connecting-rod bearing fastened to connecting-rod halves, (5) bearing surface for piston pin, (6) piston pin held securely at this point to prevent turning, (7) piston pin held unmovable in piston, (8) bearing surface for piston pin, (9) shims, (10) arrangement of shims with a heavy shim on both sides of thin ones to keep bearing from turning, (11) removable connecting-rod bearing, (12) bearing cap.

usually be done in a machine shop. The cost is small compared with the satisfactory service resulting from such work. When the piston pin and bushing or bushings are assembled, the piston *must* be aligned correctly with the connecting rod or it will bind in the cylinder and cause excessive wear. Aligning must be done in a machine shop. Be sure that the part which holds the piston pin in place is securely fastened.

Connecting-rod bearings require very little adjusting if the operator has been careful to use good oil and to keep dirt from getting into the crankcase, unless the crankshaft gets out of round. Most late tractors are equipped with the new inexpensive precision-type, steel-back, babbit-lined crankshaft and connecting-rod bearings (*Fig. 14*). These bearings are machined to fit the shaft without scraping and have no shims for adjusting. Electric hardening practically does away with crankshaft wear, and any wear that does occur is usually in the connecting-rod bearing. Bearing wear is taken care of by installing new bearings. Wear in this type of bearing is checked by forcing oil from a special tank thru the engine pressure lubricating system and noting the rate of oil flow from each bearing. Too much oil flowing from a bearing may cause excessive oil consumption and lower the oil pressure.

When fitting the older type of connecting-rod bearings, keep in mind that in some of these bearings the shims are the only means of

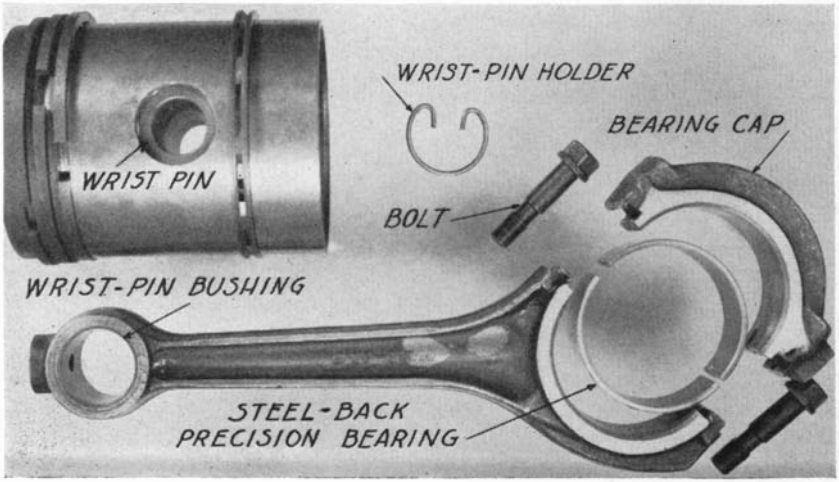

Fig. 14.—Improved type of piston and connecting-rod assembly

Wrist pins are held in by snap rings which allow freedom of movement. Connecting-rod bearings are the new steel-backed type, requiring no shims or scraping in fitting.

holding the bearings in place and preventing them from turning. These shims should be inspected for wear at the place where the bearing fits up against them, and replaced if wear is noticeable. It is customary to use two heavy shims on each side of the bearing with thin shims placed between them (*Fig. 13, item 10*). If the bearing edges that fit against

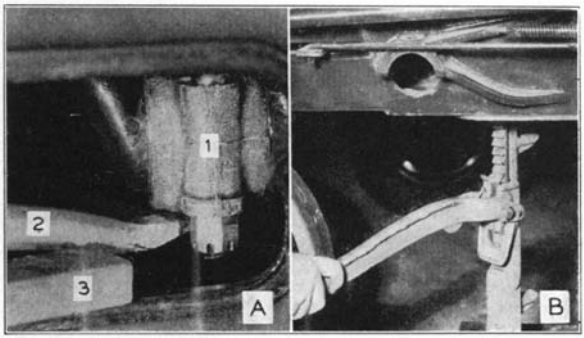

Fig. 15.—Testing connecting rod and crankshaft for loose bearings

A. Method of testing connecting rod bearing for looseness: (1) connecting-rod bearing, (2) bar for prying, (3) block of wood.

B. Testing crankshaft for vertical play by moving shaft up and down with jack.

the shims are worn off and do not fit up tightly, the edges may be built up with solder and then dressed down even with the bear cap edge.

If there is enough play in the bearings to require taking up (*Fig. 15-A*), proceed as follows:

1. Mark all bearing halves beginning with front cylinder and proceeding to the back on side next to camshaft, if this has not been done by the manufacturer. This precaution will prevent putting bearings on wrong.

2. Remove enough shims of equal thickness from each side of the bearing to be adjusted to take up most of the play. Tighten the nuts firmly with a socket wrench and check the bearing for tightness. When the bearing gets to the place where the removal of the thinnest shim, approximately .002 inch, makes the drag too hard or the fit too tight, then replacing this thin shim should give the proper fit. Bearings that are thoroly worn in do not need to be tightened so much that they bind.

3. When one bearing has been adjusted, loosen it and adjust the next. When all the bearings have been checked, tighten them all and see that the crankshaft turns freely.

4. Be sure to insert new cotter keys to keep the nuts from working off the bolts. Never loosen a nut to line up the holes so that a cotter key can be inserted—make it tighter or file off the nut. Do not tighten the nuts enough to strip the threads.

5. To prevent sides of rod from binding allow a small amount of sidewise play of the connecting rod on the crankshaft. This play may vary from .004 to .012 inch according to the engine.

When a bearing in the engine burns out, find the cause for the bearing failure and correct it before installing a new bearing and running the engine. An obstruction in the pressure oil pipe leading to a bearing usually causes the bearing to burn out. Since babbitt from the bearing is likely to enter the oil lines, it is very important that all of these passages be cleaned and inspected. A tire pump can be used to force air thru the pipes and passageways.

Never allow an engine to be run with a bearing knock. A loose connecting-rod bearing will soon pound the crankshaft out of round, so that the bearing cannot be kept adjusted.

Main bearings should be checked for end-play and up-and-down play each 700 to 1,200 hours of use. Altho these bearings seldom give trouble, they gradually wear, chiefly because of poor lubricating oil, thin oil, and the accumulation of dirt and grit in the crankcase.

Play in the main bearings on some engines can be checked by removing the crankcase inspection plates and prying up and down on the crankshaft (*Fig. 15-B*). This same method can be used for testing connecting-rod bearings if one holds the connecting rod down with the hand from the top while prying up from underneath. If the hand holes are not present, remove the oil pan and use a jack to work the crankshaft up and down (*Fig. 15-B*). A bar can be used to pry the crankshaft endwise to check the end-play, which may vary from .004 to .008 inch.

Usually any one of the main bearings can be adjusted for wear without removing the engine. Be sure the bearings are marked on the side next to the camshaft so that they can be replaced correctly. If the bearing has shims, remove the bearing cap, take out a thin shim on either side, and tighten the bearing again. Follow the method discussed under connecting rods with this exception: when one bearing is adjusted it is tightened up before the next one is loosened. If the engine has been removed and is turned upside down, then adjust the bearings as described under connecting rods.

If there is felt packing around the front and rear main bearings to prevent oil leakage, it must be carefully handled and replaced. It is often best to put in new packing.

If there is too much end-play, it is usually due to the wearing off of the thrust flange on the main bearing or bearings. A new bearing may need to be installed. It may be advisable to secure expert advice on

this problem. Some bearings are installed without scraping, but if scraping is necessary it should be done by a competent mechanic. Be sure that the nuts holding the main bearings are securely fastened.

Crankshafts sometimes are pounded out of round at the crankpin bearings by the action of the connecting rods. When the crank-throw bearing is so much out of round that the connecting rods cannot be kept tight, the crankshaft must be machined round or exchanged for a reconditioned shaft. Some tractor companies exchange crankshafts and supply new bearings at a very low cost.

Oil pumps are usually of the gear type and require little care. Inspect the pump when the oil pan is off, however, so as to detect excessive wear, which will reduce the oil pressure. Wear may take place

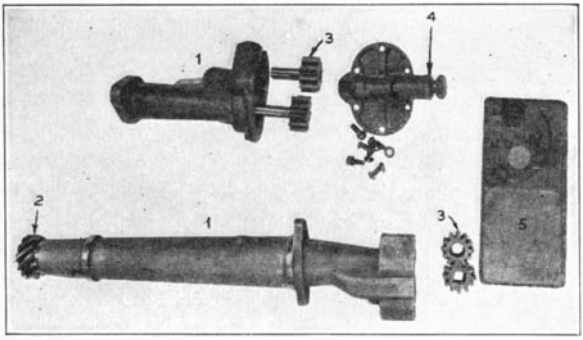

Fig. 16.—Gear pumps for circulating crankcase oil

(1) Pump housing, (2) pump driving gear, (3) oil pumping gears, (4) adjustment for regulating oil pressure, (5) oil screen.

between the gear teeth and the outside of the housing, or the gears may wear a recess in the lower plate which holds them in place, allowing them to drop lower (*Fig. 16*).

Oil pans collect quantities of dirt, grit, and sludge, and need to be removed and washed every 700 to 1,200 hours. The inside of the engine should be washed with gasoline. When replacing the pan, be sure the gasket is in good condition or loss of oil may result.

Oil screens should be cleaned after each 700 to 1,200 hours of use, or more often if they are easily removed. Watch to see that all corners of the oil screen are soldered or sealed, and that there are no holes to let larger particles of material into the oil pump to be circulated thru

the motor. These large particles often stop up some of the oil holes and cause bearings to burn out.

Many oil pumps are now equipped with the floating type of oil screen (*Fig. 17*), the screen being hinged to the pump so that it can float on top of the oil. This system supplies the clean oil from the top of the sump to the engine and prevents water and sludge from clogging

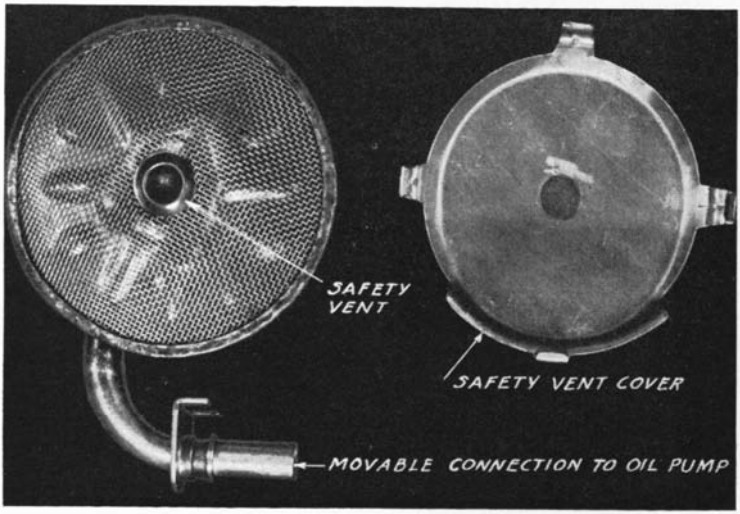

Fig. 17.—Floating oil screen used on many later tractors, cars, and trucks

This screen floats at the surface of the crankcase oil, drawing oil from the cleanest area. If the screen clogs, the pump suction pulls the screen away from the metal plate, allowing oil to enter the hole.

the screen. If the screen clogs, the pump suction pulls the hole in the screen away from the cover plate, against which it rests, and allows oil to flow to the pump.

Oil filters are desirable additions to tractors. They take out much of the foreign material that is circulated with the oil. On most tractors they need cleaning or changing each time the oil is changed (*Fig. 18*).

Most oil filters are equipped with replaceable elements made of filter paper or cotton waste (*Fig. 19*). These elements are often taken out and new ones inserted each time the oil is changed. If the element is made of loose clay or baked porous clay, it should have a cloth cover to prevent any loose particles from getting into the crankcase. This latter type of element, made of clay, is objectionable if it removes the chemical additives used in the new heavy-duty crankcase oils.

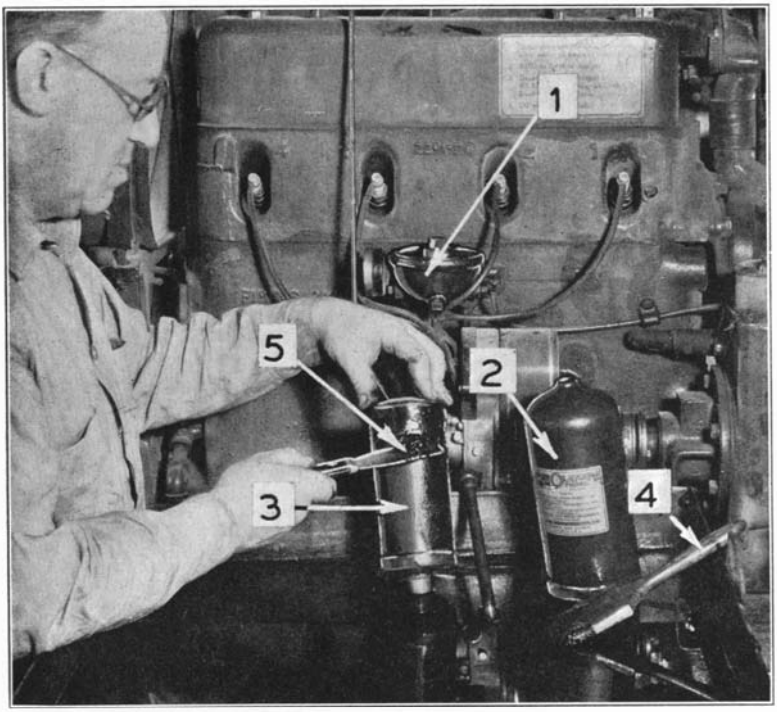

Fig. 18.—Cleaning the crankcase oil purifier

(1) Oil-purifier base, (2) cover, (3) filter unit, (4) brush for cleaning, (5) removing dirt accumulated on metal filter. Remove varnish by soaking in a strong lye solution.

Oil-pressure gages sometimes become worn or broken and do not register the correct pressure. Before condemning the oil when the pressure is low, try another gage that registers correctly. If the gage is all right, low pressure may be due to thin oil or to wear in the bearings which allows the oil to escape too rapidly. Some engines have an adjustment for increasing the oil pressure, but it is usually better to remedy the trouble than to change the adjustment. *Consult the instruction book or your dealer about changing this adjustment.*

Clutch wear takes place very slowly unless the clutch is abused by the operator's slipping the clutch to slow down the tractor speed or allowing the foot or hand to rest on the clutch pedal or handle. A new clutch may need some adjusting until it is worn in smoothly. Most clutches are of the single-disk dry-plate type and oil must be

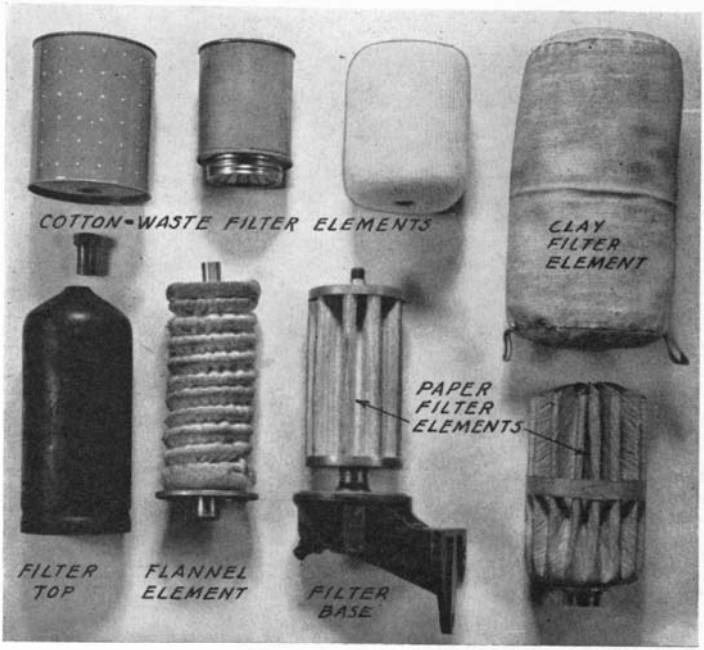

Fig. 19.—Types of filter elements for cleaning crankcase oil

Paper elements and elements filled with cotton waste are most commonly used in crankcase oil filters. Filters must receive good care.

prevented from getting on the plates. If oil gets on the clutch plates, it can be partially removed by washing the plates with gasoline.

The clutch should be adjusted so that it will not slip when the tractor is pulling its full load. *Consult the instruction book for details on the adjustment of the clutch.*

When the clutch is released, considerable pressure must be applied to the clutch throw-out bearing or clutch yoke to overcome the spring pressure. This bearing must be greased as instructed or it will wear rapidly. Usually some clearance is left between the lever or pedal that disengages the clutch, and the throw-out bearing. Check this carefully. If tightening will not prevent slipping, new friction plates or springs may be needed, or the slipping may be due to an overloaded tractor.

Engine supports sometimes work loose and need to be tightened. Engines having the front supported at one point are subject to wear at this point, which allows the engine to move, often destroying the water-hose connections between the radiator and the engine. If wear

exists at this point and no adjustment is provided, build up the support by welding or brazing and dress it down to fit.

Governor adjustment is very important on a tractor engine. Using a reliable speed counter (*Fig. 20*), test the engine speed at the end of the crankshaft, the belt pulley, or the breaker-point end of the magneto armature. Check for the governed speed of the engine at "no load,"

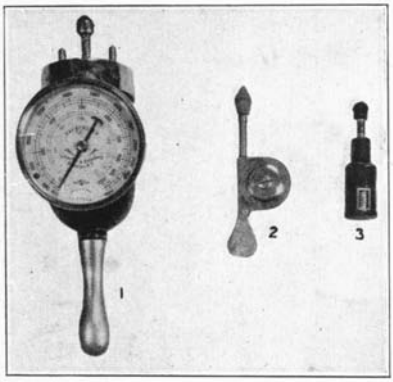

Fig. 20.—Speed Counters

(1) Direct-reading speed counter, (2) accumulative speed counter reading to 100, (3) accumulative speed counter reading to 10,000.

which will be somewhat faster than the working speed. If a speed counter is not available, have the dealer check the engine speed. *Do not run the engine faster than the manufacturer's listed idling speed.*

Wear in the governor parts may cause slow engine response to the action of the governor.

FUEL SYSTEM AND CARBURETOR

Fuel systems become clogged from dirt and rust and require a thoro cleaning at least once a year. If the fuel tanks are kept full while standing, inside sweating and water accumulation will be reduced to a minimum.

Remove all the fuel lines and blow thru them. Remove the fuel tank, clean it out, and inspect it for wear and rusted places. The felt padding between the support and the bottom of the tank often wears thru allowing the tank to rub. Felt packing from a horse shoulder pad, leather, or rubber will make a satisfactory rest for the tank. *If the gas tank needs to be soldered, take it to a repair shop.* Do not try to make

the repair yourself—it is extremely dangerous unless one is experienced in such work. Clean all the fuel screens and test all connections for leaks.

Carburetors may be the source of considerable engine trouble. The same carburetor is used for gasoline and low-grade tractor fuels, but it requires adjusting according to the body (viscosity) of the fuel. The heavier fuels require a slightly larger opening of the needle valve (*Figs. 21-24*). If two kinds of fuel are to be used, the main fuel jet should have an adjustable needle valve. Old carburetors may show considerable wear and need careful checking by an implement dealer. A properly repaired and adjusted carburetor will easily save 3 to 5 gallons or more fuel for each day's use.

The needle valve in some carburetors may have a ring worn around it where it has been screwed down on the seat. This wear prevents the

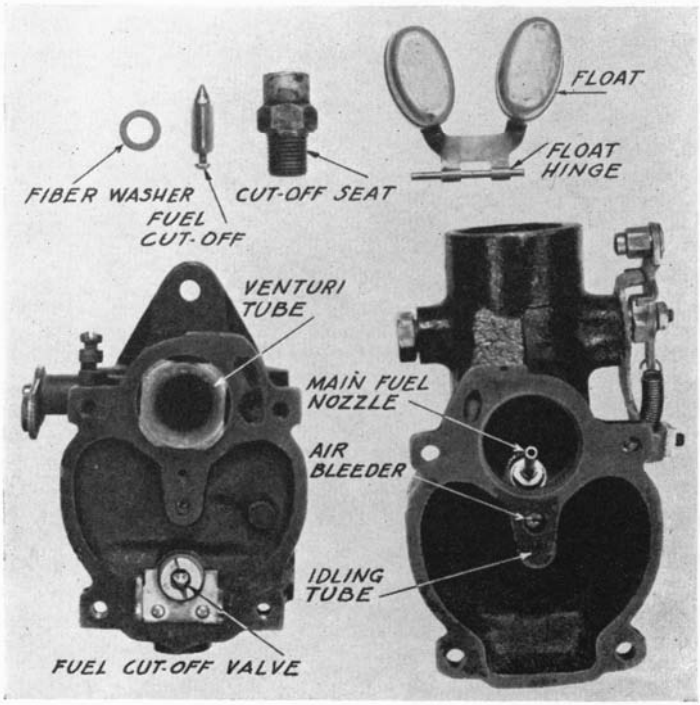

Fig. 21.—Parts of a tractor carburetor

Modern tractor carburetors require proper servicing. Wear takes place in float hinge, fuel cut-off, and seat, causing the fuel level in the bowl to change; this increases fuel consumption.

proper adjustment of the carburetor. If the point of the needle valve is not in very bad condition, it can be repointed. Sometimes both the needle valve and its seat can be replaced.

The float chamber cut-off shuts the fuel off from the carburetor when the bowl fills to the proper level. Any leakage from the bowl is

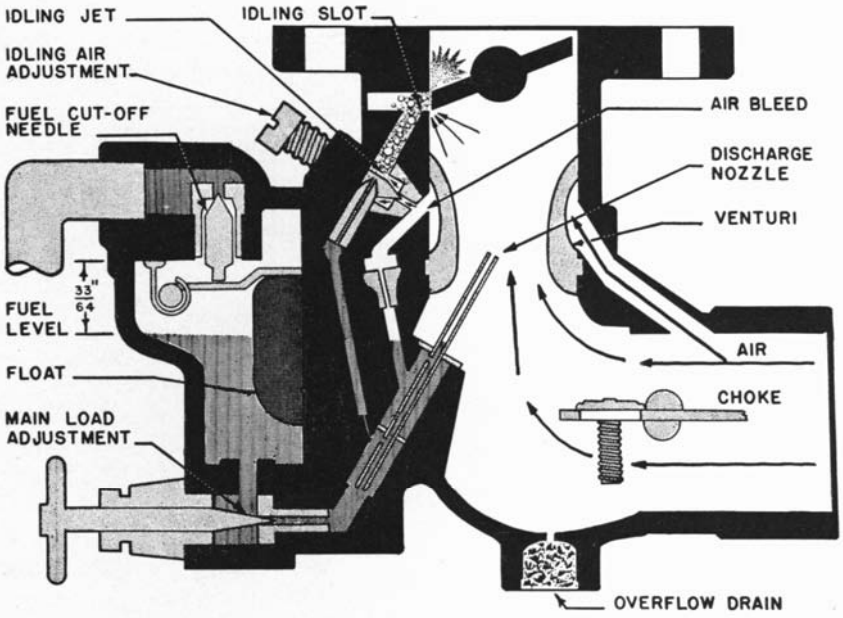

Fig. 22.—Air-bleeder tractor carburetor operating at idling speed

Air passing edge of throttle valve forms a vacuum, causing fuel to flow up the small idling tube, where it mixes with air from the idle air adjustment to form a combustible mixture. The main discharge nozzle is inoperative at idling speed.

usually due to something under this valve, or the valve may be so badly worn that it will not seat properly. Tapping the carburetor bowl sharply may dislodge the dirt. If the cut-off valve and seat are worn, replace both these parts. Repair replacements for these parts are usually carried by the implement dealer.

The purpose of the float is to maintain the proper fuel level in the carburetor, in order to prevent carburetor leakage and excess fuel consumption. In old carburetors the float may be worn at its hinge and where it rubs against the cut-off. If the cut-off holds properly, replace the worn float parts and then change the thickness of the fiber washer

under the cut-off housing to bring the fuel to the proper level (*Fig. 21*). The proper fuel level is often listed in the instruction book or it may be obtained from the company; it can be checked by using a short piece of glass tubing and rubber hose (*Fig. 25*).

When metal floats are used, holes may occur which must be soldered, care being taken to remove all excess solder which, if left, would increase the weight of the float. When cork floats are used, the shellac coating may become cracked, allowing the float to soak up fuel and thus become heavy. Secure a new float if possible; otherwise clean

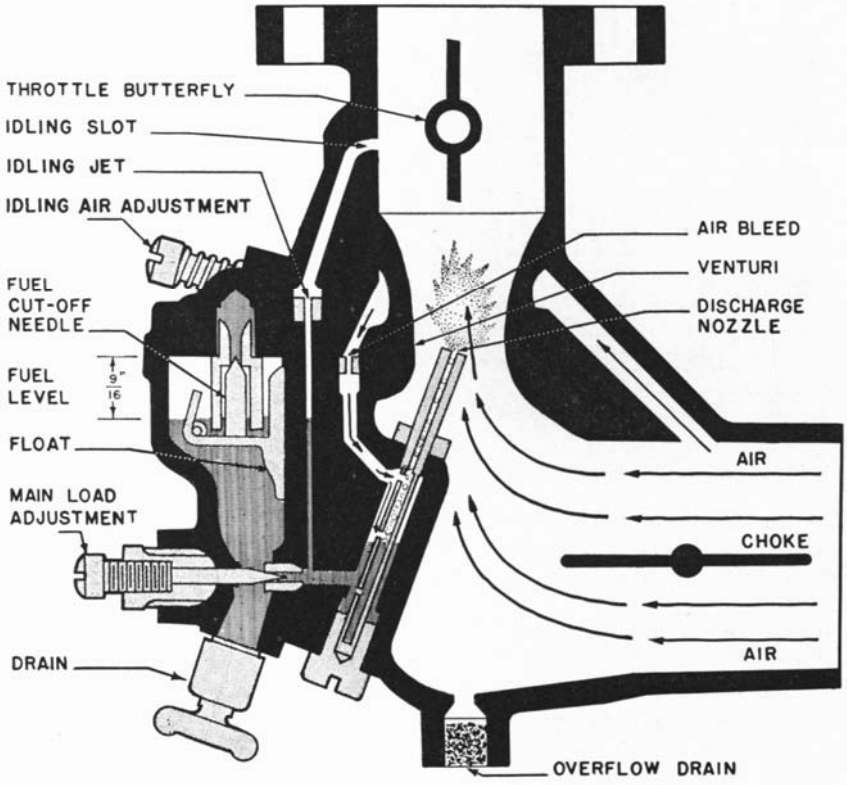

Fig. 23.—Air-bleeder tractor carburetor operating at full load

When the throttle is opened part way, the air flows past the discharge nozzle with enough velocity to cause the fuel to flow out. As the engine speed increases, the fuel is lowered in the nozzle, allowing air to enter at its base, and displace some of the fuel, thus preventing the mixture from becoming too rich. The idling system operates only when the throttle is closed.

off the shellac, dry the float thoroly, and then apply two coats of high grade shellac.

The choke should work freely, and one should be careful to see that it opens up completely in order to prevent excessive fuel consumption.

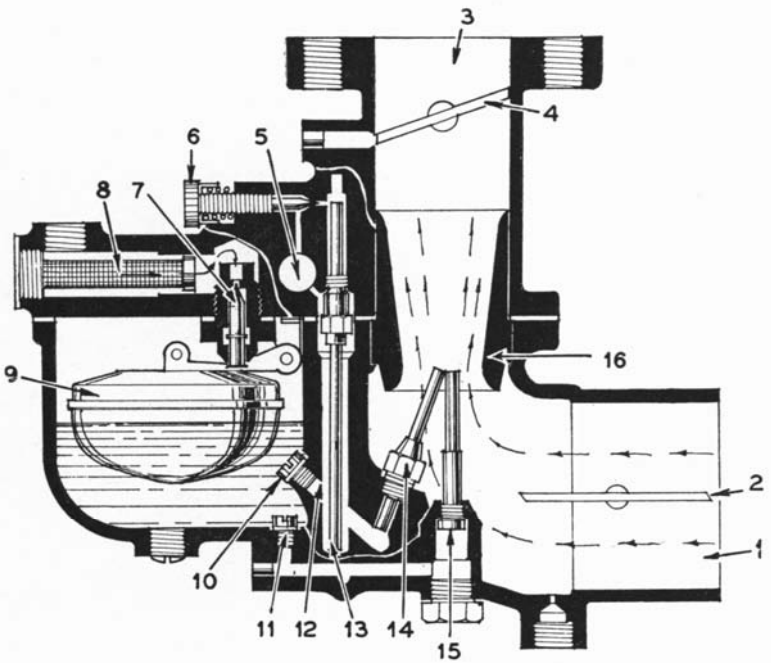

Fig. 24.—Automatic type of carburetor with adjustable idling device

(1) Air intake, (2) carburetor choke, (3) outlet to engine, (4) butterfly throttle, (5) air passage supplying compensating jet, (6) idling needle valve, (7) float valve cut-off and seat, (8) fuel screen, (9) float, (10) constant-flow opening supplying gas, (11) main jet feeder, (12) compensating well, (13) idling tube or jet, (14) compensating jet, (15) main fuel jet, (16) venturi tube.

Butterfly valve is the name applied to the throttle valve and the choke valve of the carburetor. The shafts that hold these valves extend thru one side of the carburetor for the purpose of attaching the controls; they must fit the holes snugly or air and dirt will enter the engine. The air may cause hard engine starting and uneven running, and the dirt will cause wear.

Air cleaner servicing is one of the most important jobs in the daily

care of the tractor. The dust entering a tractor working under very dusty conditions without an efficient air cleaner may cut out the cylinder walls, pistons, and other rubbing parts of the motor to such an extent that in 10 to 15 days new parts will have to be supplied.

Follow the manufacturer's directions exactly in caring for the air cleaner. Each 300 hours, or more often under extreme dust conditions,

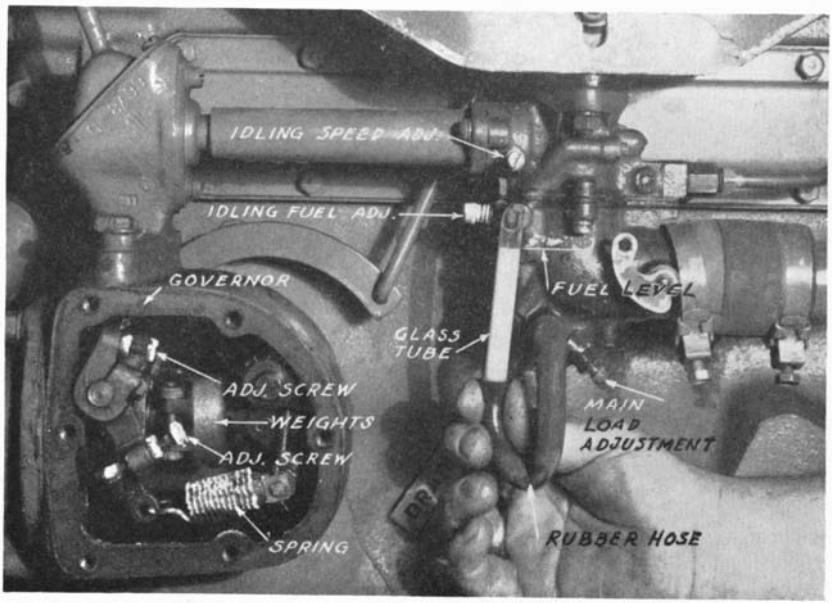

Fig. 25.—Carburetor float level should be checked once a year

Improper level of fuel in the float chamber causes high fuel consumption. To check the fuel level, mark the fuel-level point on the carburetor bowl, place a rubber tube over the drain plug, and check the fuel level in the glass tube with the mark on the bowl. If fuel level is incorrect, have carburetor repaired by a dealer.

remove the entire air cleaner in types where the filter element is not removable, wash it inside, dip filter part in oil, and assemble the cleaner (*Fig. 26*). Dirt which collects in the air intake pipe to the air cleaner must be removed when the cleaner is washed. Vegetative matter such as soybean fuzz, chaff, and dandelion seed collects on the filter element of the air cleaner, restricting the air flow to the engine and greatly reducing its power. Daily care of the cleaner is absolutely necessary. If the cup is allowed to fill with dirt, the amount of oil will

be reduced (*Fig. 28*) to the point where it will not do a satisfactory job of cleaning. Most cleaners have oil in a cup at the bottom and it is essential to use oil of the proper body in the cup (*Fig. 27*). The usual recommendations are as follows:

1. Use the same oil in the air-cleaner cup as is used in the engine crankcase, but never use heavier than SAE 30. Used crankcase oil is not recommended for air cleaners, but used oil from the air cleaner may be used again after it has settled.

2. For temperatures as low as 15 degrees or more below zero, add 10 percent of kerosene to SAE 10W oil.

Connections to the air cleaner must be inspected frequently for air leaks. Always maintain air-tight connections at the joints and replace these parts when necessary.

Fig. 26.—Washing filter or air cleaner

(1) Oil cup, (2) oil level, (3) main body of cleaner containing wire filter, (4) washing filter with kerosene or gasoline.

Air breathers are provided on most tractors for the purpose of ventilating the crankcase and the transmission (*Fig. 27B, item 4*). If these are of the filter type, follow the instructions given for their care.

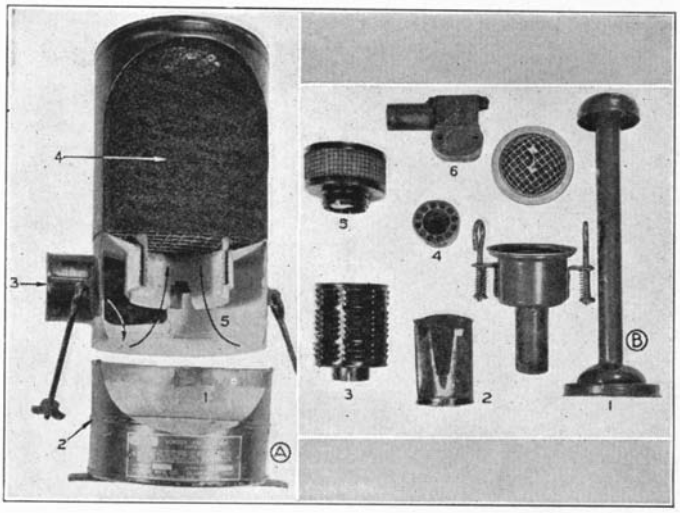

Fig. 27.—Types of air cleaners and air breathers

A. Oil-type air cleaner: (**1**) oil sump, (**2**) oil level, (**3**) air inlet, (**4**) fine wire filter, (**5**) air outlet.

B. Types of crankcase air breathers: (**1**) breather with removable filter unit, (**2**) section of a breather filled with fiber filter, (**3**) breather filled with fine wire filter, (**4**) small breather cap filled with fiber, (**5**) breather covered with several thicknesses of fine wire, (**6**) breather filled with steel wool.

If instructions are not available, wash the filter and dip it in oil every 10 hours. Most tractor crankcase ventilators have only one opening or breather for the escape of the air that blows by the pistons. If this breather becomes clogged, oil will be forced out past the gaskets and front and rear main bearings.

Dirt in the working parts is your worst enemy. Before removing any part of the tractor — inspection plates, plugs, or covers — be sure to clean all dirt or foreign matter away from these points.

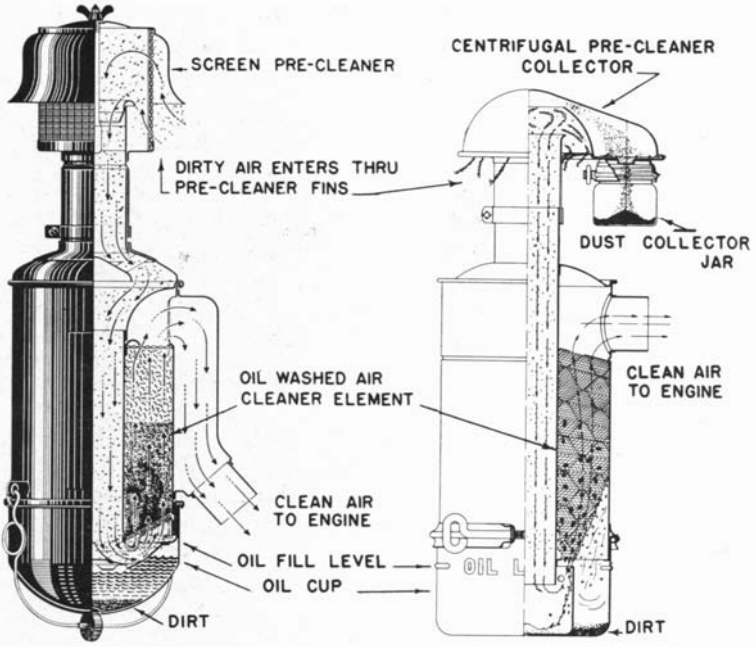

Fig. 28.—Oil type of air cleaners (cross-section). Dust-laden air entering the cleaner on its way to the engine passes thru a bath of oil and a metal filter-screen, which removes 99 percent or more of the abrasive dust. The dry centrifugal precleaner attachment is desirable because it collects much of the dust that would otherwise lodge in the bottom of the cleaner oil cup. Daily care of the air cleaner is extremely important to the life of the engine.

THE IGNITION SYSTEM

The ignition system of a tractor usually consists of a high-tension magneto equipped with an impulse starter (*Fig. 30*), altho the battery system is being used on tractors with heavy-duty truck types of engines that burn gasoline only. This magneto is a complicated piece of equipment and any extensive repairing should usually be done by an expert.

Present-day magnetos have been greatly simplified, and some are now lubricated and sealed, requiring no further care for one or two years. The instruction book gives complete directions for taking care of the magneto—*follow it closely*. Magnetos require very little oil; over-oiling may destroy the windings inside the magneto.

When the magneto is removed to be taken to a repairman, the

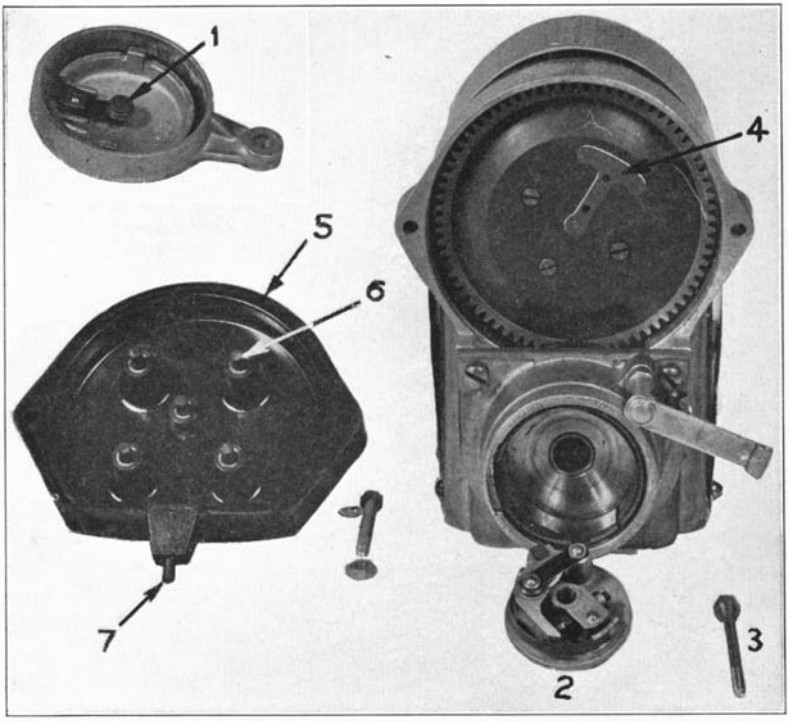

Fig. 29.—Parts of a high-tension magneto

(1) Breaker cover with ground for stopping engine, (2) breaker (interrupter) assembly, (3) screw for attaching assembly, (4) distributor disk, (5) distributor cap, (6) distributor brushes, (7) collector brush for high tension current.

directions in the instruction book for its retiming must be followed *exactly*. There are, however, a few places on some magnetos which the operator must take care of, and the following suggestions may be helpful in securing better service from the magneto. Before opening any part of a magneto make certain that all the dirt and dust is removed.

Breaker points, when separated, stop the flow of low-voltage current which has been generated by the magneto and is flowing thru the magneto circuit. The heat at the time of the separation of the breaker points causes the points to corrode and burn, eventually making poor contact (*Figs. 29-37*).

Breaker points are made of two types of material—platinum and tungsten—both of which resist corroding and burning to a high degree. Platinum points, now seldom used, are soft enough to allow filing; but

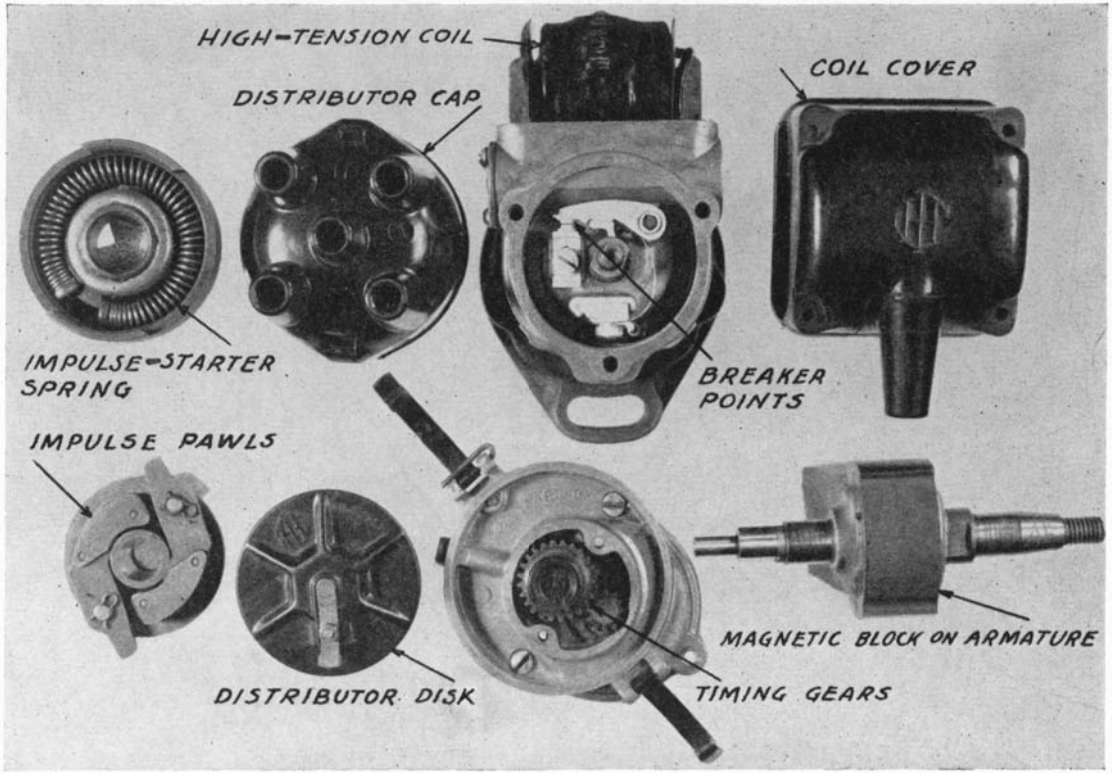

Fig. 30.—Parts of new inductor high-tension magneto. This smaller simplified magneto is made possible by mounting a small block of new magnetic metal on the armature in place of the usual wire coil. The stationary mounting of the high-tension coil insures longer life to the coil and simplifies repair work.

tungsten points, most commonly used, are extremely hard and can be dressed only by using a carborundum strip or an oil stone.

If the breaker points on a new magneto are easily inspected, they should be checked each 100 hours of operation until the tractor has run 300 hours, after which inspection at intervals of 300 hours will be enough. This can be done by removing the breaker cover and pushing the points apart. Any scale or corrosion can usually be scraped off, but if the points are pitted they must be dressed until all signs of the pits are removed. After the points have been properly dressed, check the distance between them when they are separated by the cam. This distance must be maintained at .012 to .020 inch at all times (*see instruction book*). When an automatic impulse starter is used on a magneto, it is difficult to stop the engine so that the breaker points are held wide open. If this difficulty is encountered, turn the engine until

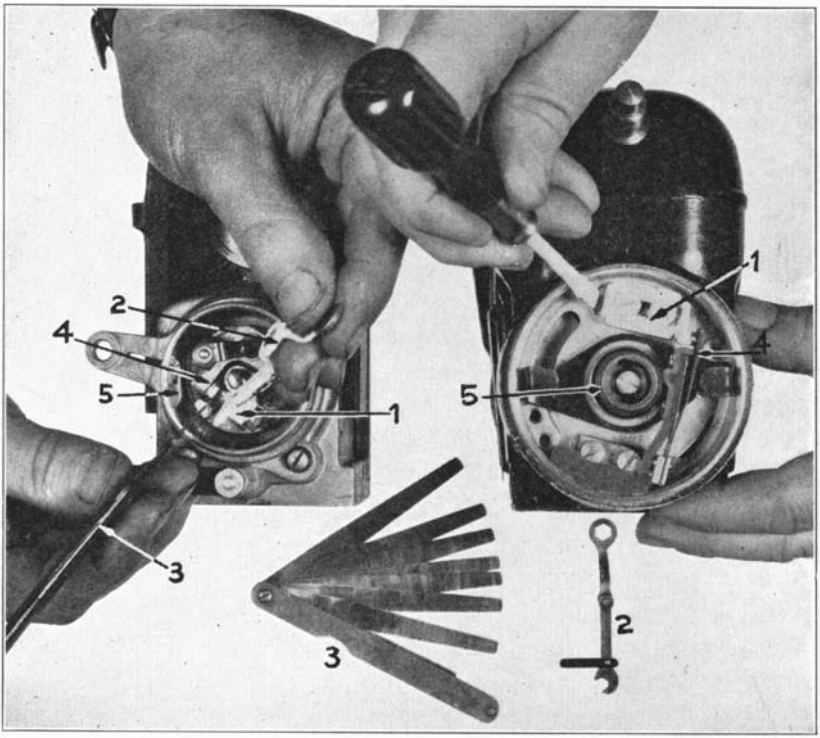

Fig. 31.—Adjusting breaker points for gap clearance

(1) Insulated adjustable breaker, (2) magneto wrench with breaker gap gage, (3) thickness gage, (4) movable breaker point, (5) cam for opening breaker points.

the impulse starter trips, and then back the engine up until the points open. The engine can usually be turned backward with the belt pulley or by squeezing the fan belt together and turning the fan backward. On some older magnetos the impulse starter pawls can be held out of working position, and the engine turned until the breaker points are wide open. For checking the gap between the points use the gage attached to the magneto wrench (*Fig. 31*). If the magneto wrench has been lost, use a thickness gage to set the points. Make sure that the spring operating the movable breaker point works freely and exerts enough pressure to hold the points together firmly.

The ground brush on a magneto, when used, extends from the side or bottom of the magneto frame to the armature frame and helps to make a better contact between the frame and the armature (*Fig. 32*).

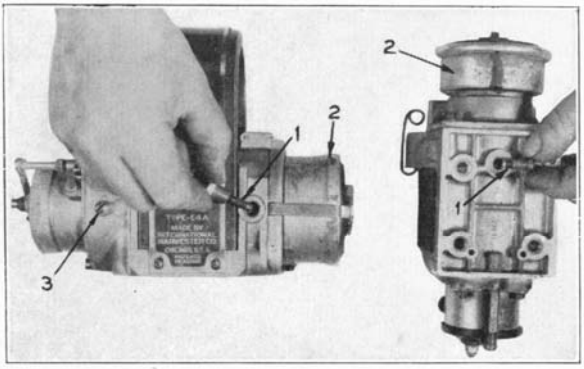

Fig. 32.—Magneto ground brush

(1) Ground brush, (2) impulse starter, (3) safety spark-gap screw.

This brush should be removed and inspected each 1,500 hours to see that it has not become glazed, which would prevent it from making good contact. If the brush is glazed, dress it with fine emery cloth. A new brush may need to be installed after a time.

Impulse starters provide a method of increasing the speed of the magneto when the engine is being cranked (*Fig. 30*). This mechanism works as follows: A spring from the drive shaft of the engine drives the magneto. Just before the engine cylinder is ready to fire, the magneto armature is stopped and the spring is wound up until the engine piston reaches the end of the compression stroke. Then the spring is released and flips the magneto armature around thru the place

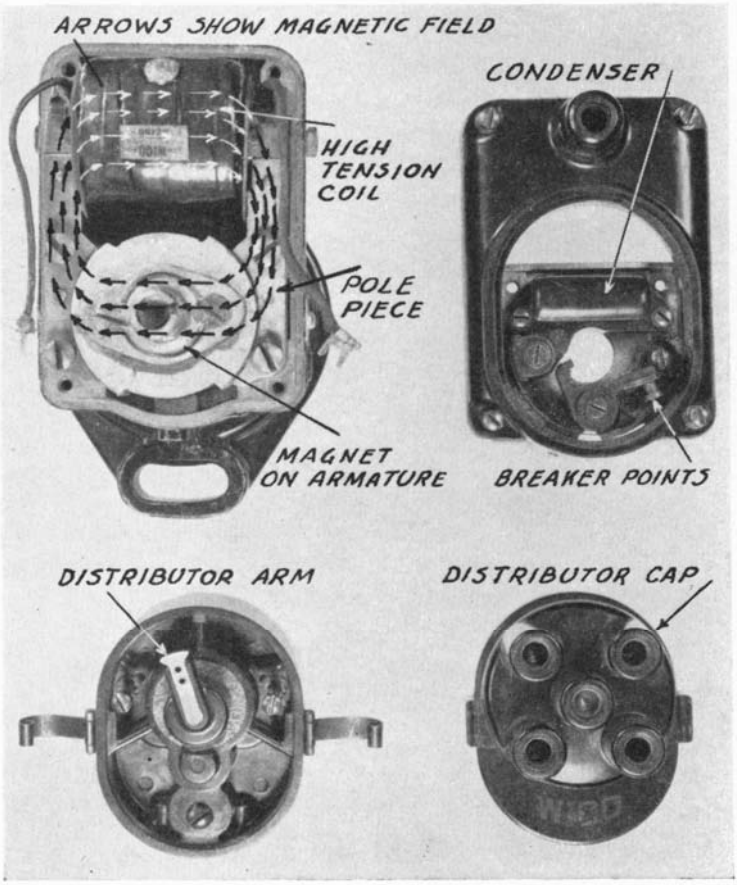

Fig. 33.—Simplified construction of high-tension magneto

The various parts of the magneto are grouped and easily removed for inspection. The path of the magnetic field is shown by arrows.

where the spark is produced. When the engine starts, the pawl which stops the armature is thrown out of position by centrifugal force and remains in this position as long as the engine runs.

If the impulse starter collects enough dirt to cause it to stick, it can be cleaned with kerosene or light oil (*see instruction book*).

Distributor caps and disks on magnetos where carbon brushes are used collect carbon, which sometimes short-circuits the high-tension spark. Once or twice a season remove the cap and using a rag moistened with gasoline wipe off the distributor disk where the brushes rub

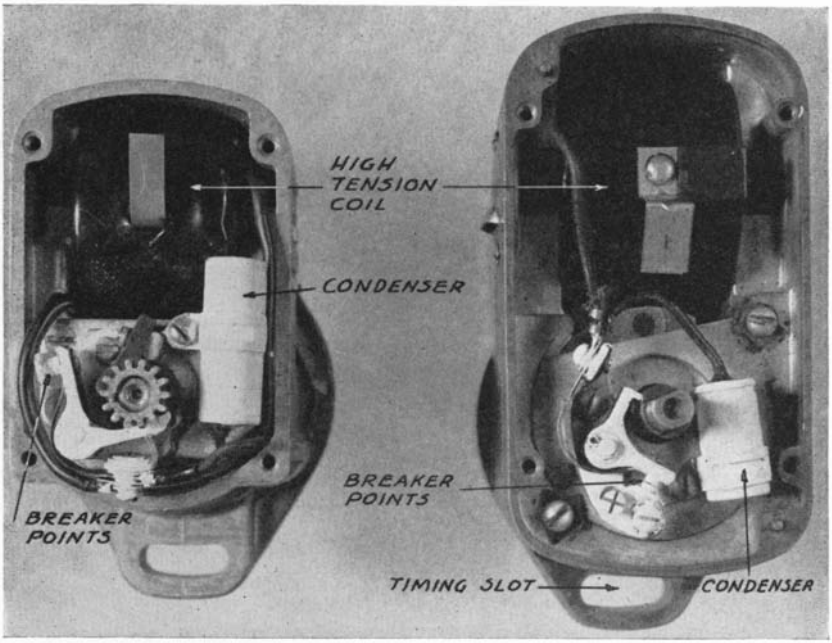

Fig. 34.—Magneto breaker-point and condenser location
These parts are readily accessible for inspection and repair or replacement.

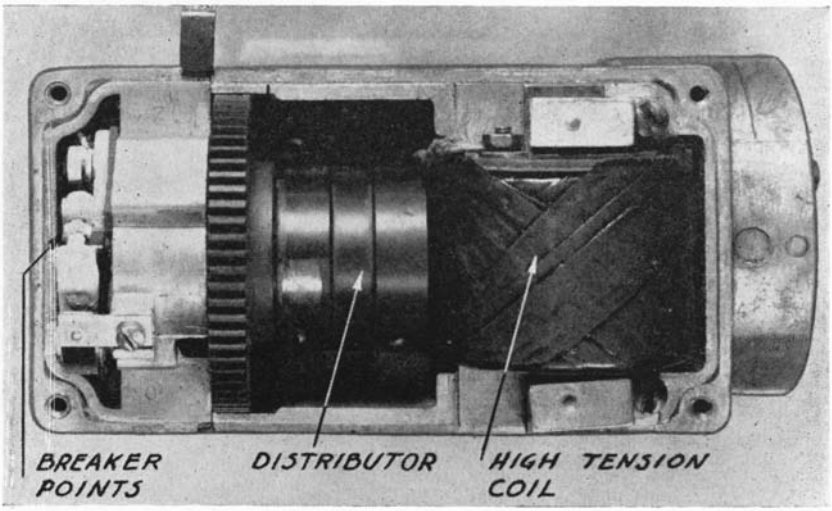

Fig. 35.—Early type of inductor magneto
Still used on older tractors, this magneto is hard to inspect and repair.

(*Fig. 36*). Be sure the brushes all work freely and make good contact with the distributor disk.

Dust seals are provided at all places on the magneto where dust can damage the working parts. These seals are usually made of felt and should be carefully inspected before the particular part is replaced on the magneto.

Magneto timing is thoroly discussed by most instruction books. The manufacturer will gladly supply a new book when needed.

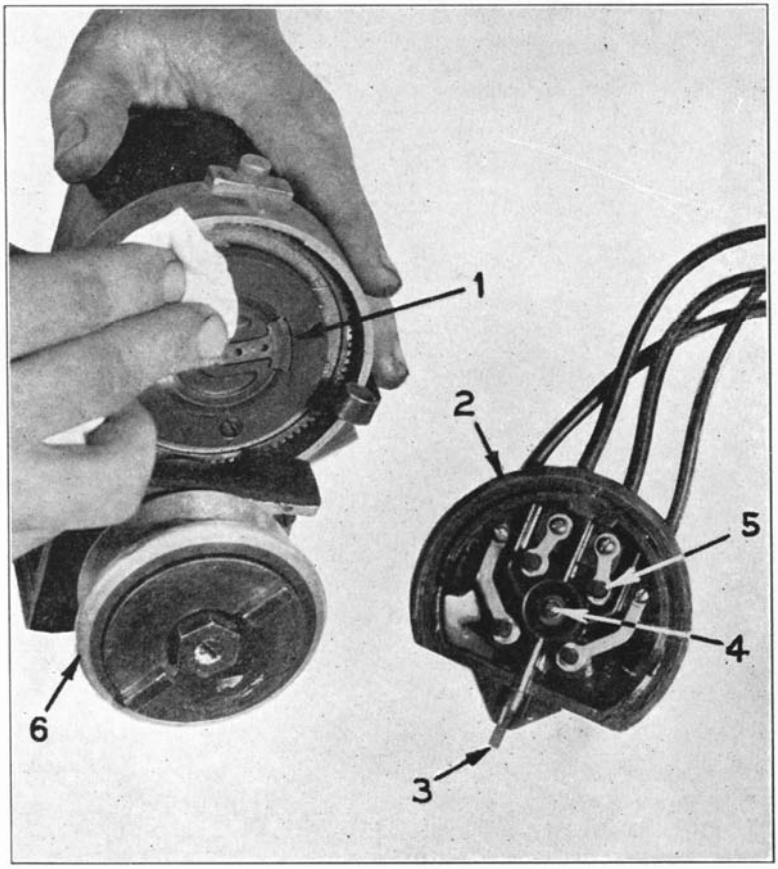

Fig. 36.—**Wiping carbon from distributor disk**

(**1**) Disk, (**2**) housing, (**3**) high-tension pick-up brush, (**4**) high-tension delivery brush, (**5**) spark-plug-wire pick-up brush, (**6**) impulse starter.

Battery-type ignition is now being used on the heavy-duty type of gasoline-burning truck engines found on tractors. This is the usual type of ignition found on automobiles, and the breaker points and distributors require about the same care and inspection as those on the magneto. A special type of tractor battery ignition unit is shown in Fig. 37.

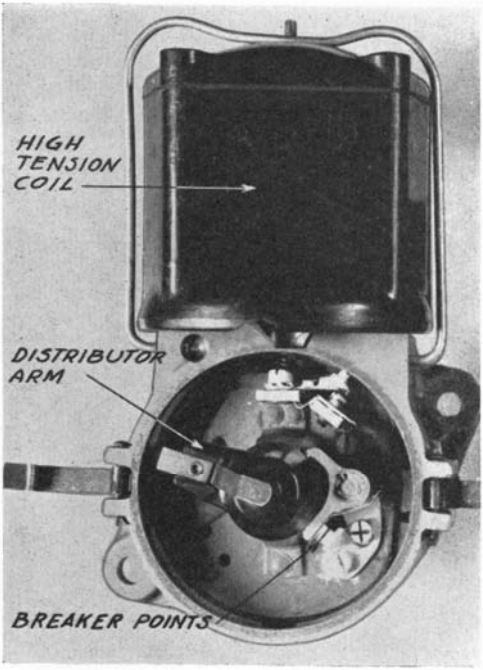

Fig. 37.—Automobile type of battery ignition for tractor

This type of ignition is used on several makes of gasoline-burning tractor engines in place of the magneto. The coil in this unit is attached to the breaker-point housing.

Spark plugs should be adapted to both the fuel used and the operating temperature (water) of the engine. Different types of engines vary widely as to operating temperatures, and spark plugs likewise differ as to the temperatures they are able to withstand. A good set of spark plugs can be ruined in a very short time by operating them above their heat range. Even when the plugs are properly selected, engine overheating (*page 47*) is likely to cause them to deteriorate rapidly. The porcelain of a properly operating plug should have a

toasted brown color. Tractor dealers or automotive accessory dealers can give full information as to the types of spark plugs to use.

A spark plug must run hot enough when idling to prevent fouling and must remain cool enough under full-load operation to give it long life and to prevent preignition and excessive heating of the valves. It is impossible to make one spark plug that will work properly under all these varying heat conditions and with all types of fuels.

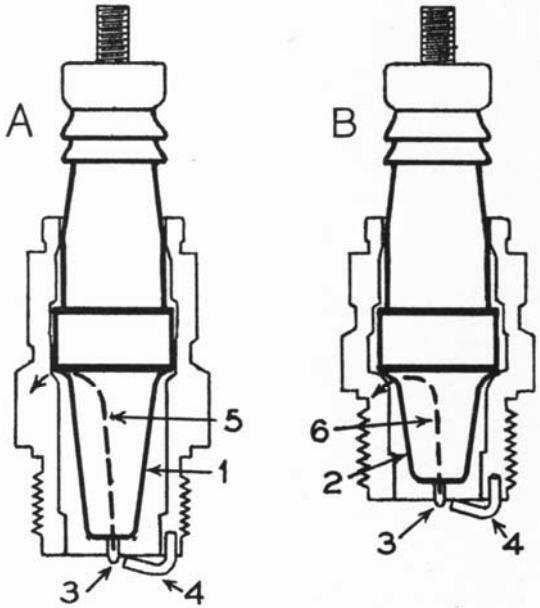

Fig. 38.—Two types of spark plugs: (A) hot, (B) cold

(1) Long porcelain, holds heat in the plug; (2) short porcelain, allows heat to escape rapidly; (3) center electrode; (4) outside electrode; (5 and 6) distances heat must travel to escape from porcelain.

Spark plugs are usually spoken of as hot plugs or cold plugs. The temperature of the spark plug is controlled largely by the length of the porcelain insulator inside the plug from the bottom sealing gasket down to the lower end. A long porcelain (*Fig. 38*) requires more time for the heat to escape and consequently causes the plug to run hot. A short porcelain allows the heat to escape rapidly and causes the plug to run cooler. For low-grade fuels the hot plug is used in order to give the proper heat for ignition and to prevent plug fouling. For gasoline the cold plug is used in order to prevent preignition and engine overheating

and consequent deterioration of the spark plugs. The all-purpose spark plug, designed for use with all fuels, does not usually give satisfaction in an engine burning both low-grade fuels and gasoline.

The points of the spark plug gradually burn away because of the intense heat in the cylinder, and the distance or clearance between them is widened to such an extent that poor operation results (*Fig. 39*).

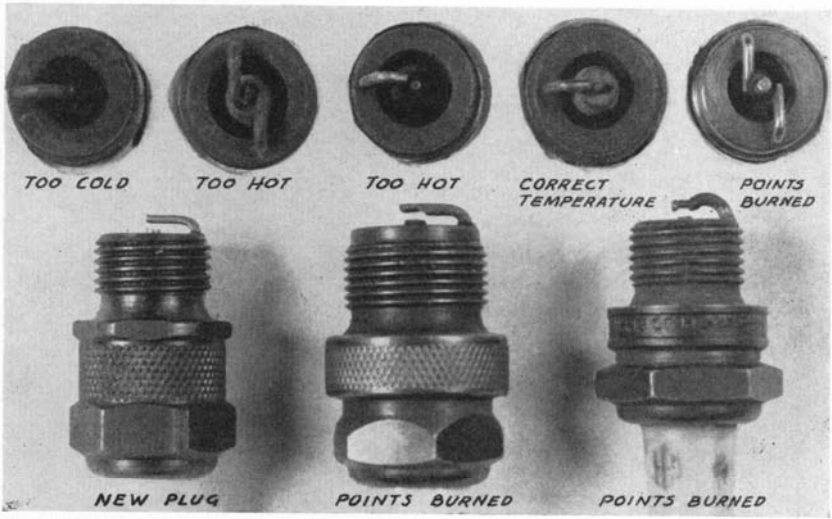

Fig. 39.—Spark-plug troubles

Improper operation of the engine results when plugs are too hot or too cold or have the point burned away. The porcelain of a properly operating plug will have a brown, toasted color.

Examine the plugs each 200 hours and check the point gap with a round-wire gage (*Fig. 40*). Keep the distance of separation between .020 and .025 inch. Always bend the outside arm when adjusting the points. Too wide a gap will cause the engine to miss fire at high speeds, and too narrow a gap will cause poor idling of the engine.

Clean the spark plugs when they are removed for inspection. The two-piece plugs are easy to clean, but they must be securely tightened when assembled. If the plug looks faulty, put in a new porcelain or supply a new plug. When using lead-treated gasolines, unglazed spark plug porcelains must be used. A faulty plug produces a weak spark.

Spark-plug cables gradually become oil-soaked and deteriorate. In this condition they are likely to allow the high-tension spark to short-circuit on its way to the plug. A short circuit causes a weak spark or

a total failure of the spark. Replace the cables if there is any doubt about their condition.

Waterproofing ignition systems can now be done with a new liquid type of insulator. This liquid, painted on ignition wires, spark plugs, distributors, and storage-battery tops, prevents water from short-

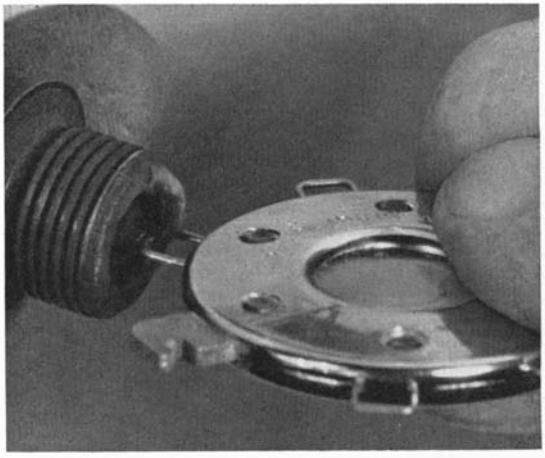

Fig. 40.—Spark-plug gaps need adjusting about every 1200 miles

The gap clearance in a tractor is usually .020 to .025 inch. Measure it with a round-wire gage, and use the hook to bend the outside arm.

circuiting the current and increases the life of the ignition parts. This liquid can be secured at implement dealers, automobile-accessory dealers, and filling stations.

THE COOLING SYSTEM

The cooling system of a tractor requires considerable attention by the operator if he is to get proper fuel economy and power from the tractor. The cooling system is designed to maintain the engine temperature at 180° to 190° F. under the hottest operating conditions. When the engine is operated in cool or cold weather, some means must be provided to keep the engine hot. An engine running too cool, especially when low-grade fuels are used, burns an excessive amount of fuel and causes dilution of the crankcase oil.

Overheating the engine is always serious because it results in loss of power and often in valve trouble and other damage to the engine. It is usually due to one or more of the following causes: (1) poor grade

of fuel; (2) improper fuel mixture; (3) spark improperly timed; (4) leaky valves; (5) improper valve-tappet clearance; (6) overloading; (7) limed and clogged cooling system (*Fig. 41*); (8) dirt in radiator fins; (9) slipping fan belt; (10) wrong type of spark plugs; (11) too heavy crankcase oil; (12) covering of radiators and hood ventilators in winter; (13) damaged thermostat.

Radiator care is essential to the proper heat control of the tractor. Use rain water to fill the radiator. Prevent all foreign material from collecting on the front of the radiator and keep the space between the radiator fins free from foreign material. Keep the radiator overflow pipe open. Clogged radiators cause engines to become overheated, a condition often attributed to other causes.

The cooling system should be drained and flushed with clean water after each 300 hours of use, in order that accumulated dirt may be removed.

CAUTION: Never pour cold water into a hot engine, or extremely hot water into a very cold engine; the sudden contraction or expansion caused by the water may crack the cylinder head or engine block. If it is impossible to let a hot engine cool before adding water, let the engine run and add the water very slowly.

Radiator scale can be removed by chemicals which loosen and dissolve it. If directions are not found in the instruction book for removing lime and scale, proceed as directed on the next page.

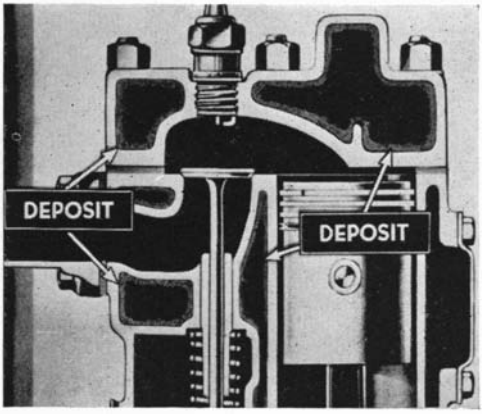

Fig. 41.—Lime deposits in the cooling system should be removed once a year

These deposits, resulting from the use of hard water, cause the engine to overheat. They can be prevented by using rain water.

1. Soda solution. Clean the radiator once a year or oftener by using a solution of strong washing soda. Determine the amount of water the radiator will hold, and fill it half full with rain water. Take the other half of the water, heat to boiling, and add all the washing soda it will dissolve. Pour this saturated washing-soda solution into the radiator while the solution is hot and run the engine for 10 to 20 hours at regular farm work, after which completely drain the radiator, flush with clean water, and refill as usual. This yearly treatment helps to prevent the scale from forming in the radiator and cooling system.

2. Hydrochloric acid. If the soda treatment will not remove the scale, a solution of hydrochloric (commercial muriatic) acid may be used. CAUTION: This acid in solution is a solvent of the metals of which the radiator is made, and it is extremely important that the directions be followed exactly.

Make a weak acid solution consisting of 1 part of hydrochloric acid and 7 parts of rain water. Drain radiator and cooling system and fill with this solution. Allow it to stand in radiator for 36 hours without running the tractor. Then drain and refill radiator with clean water and add 2 to 3 handfuls of washing soda. Run engine for 5 or 10 minutes, drain radiator, and fill it with clean water. The soda treatment neutralizes any acid that may be left in the system.

Some tractor companies recommend special compounds of their own for cleaning radiators. There are also a number of other reliable compounds on the market. Some household sink drain cleaners are also recommended by manufacturers for cleaning cooling systems.

The radiator hose needs replacing occasionally, as it becomes old and rotten with time. It may collapse inside and restrict the flow of water; and loose pieces of rubber may prevent the proper working of the thermostat.

Always check the hose and hose connections and keep them in good condition, especially when antifreeze solutions are being used. If the hose clamps do not hold, a piece of wire can be wrapped around the hose and twisted tightly, in addition to the regular clamp. Apply shellac to the hose joints to give the proper seal.

Radiator curtains or shutters are provided on most tractors for the purpose of maintaining the proper engine temperature in cool weather (*Fig. 42*). On the newer tractors the curtain or shutter is controlled from the operator's seat. Keep the curtain in good repair and use it as instructed by the manufacturer. If a curtain is not provided, it is an easy matter to make one for the radiator.

Thermostat temperature control of the cooling system is provided on some tractors. The thermostat (*Fig. 49*) is placed in the water outlet from the top of the engine to the top of the radiator. It is operated by

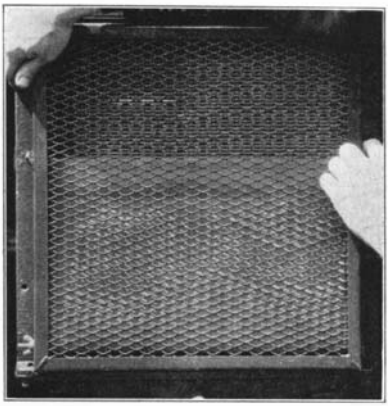

Fig. 42.—Radiator curtain for controlling temperature of engine water

On engines burning low-grade tractor fuel, the shutter should be regulated to keep the water temperature between 190° F. and 210° F.

heat and prevents the circulation of water thru the radiator until the water is thoroly warmed. Inspect the thermostat every 500 to 1,200 hours to make sure that it does not become coated with lime or other foreign material in the cooling water and fail to operate properly. Cleaning the radiator, as has been recommended, should keep this part working properly.

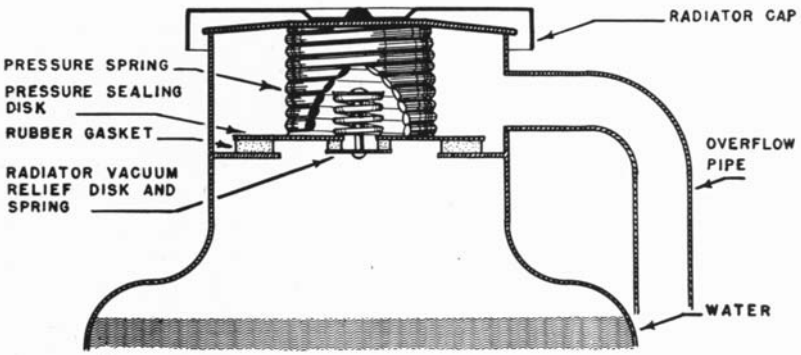

Fig. 43.—Pressure-sealed radiator cap

This type of cap prevents excessive evaporation of water from steel-finned radiators. A steam pressure of 5 pounds or more with a water temperature of 220° to 230° F. makes it dangerous to remove the cap until the engine has cooled somewhat. To prevent collapse of tubes, the small relief valve admits air as the radiator cools.

In order to know the exact radiator temperature, even tho a thermostat is used, one should equip the engine with a water-temperature gage (*Fig. 44-A*). Most tractors include this gage as regular equipment.

Pressure-sealed radiators (*Fig. 43*) are used on tractors with the new steel-finned radiators. The copper shortage requires the use of steel fins which, because of their low heat conductivity, cause the radiator to operate at a higher temperature, resulting in considerable loss of water. The radiator neck is sealed with a valve held down by spring pressure. This valve allows the radiator temperature to advance to 225° to 230° F. with 5 or 6 pounds of pressure before releasing. As the engine cools down, a small valve in the seating valve opens and prevents a vacuum from occurring in the radiator. Unless all connections are tight, the pressure cooling system will not work properly and loss of water and overheating will result. If the regulating valve fails, it must be replaced with a new one. Never remove the radiator cap until the engine has cooled somewhat. A special high-temperature water gage is necessary with this system.

Fan bearings operating at high speeds often become worn. A loose, wobbly fan causes vibration, which may result in the fan or its support breaking and seriously damaging the radiator. Replace the bearings and shaft (*Fig. 44-B*) if necessary.

Fan pulleys are fastened to the crankshaft by a key or bolt. Inspect the pulley to see that it is held tightly in place.

Fan belts should be checked after each 100 hours of use and tightened if necessary. A loose fan belt allows the fan to slip, which causes the engine to overheat.

Water pump care is very important in the proper operation of the tractor engine (*Fig. 44-C*). Some water pumps have a grease-cup fitting and require a special water-pump grease which is rather hard and will not melt and mix with the hot water of the cooling system. If ordinary cup grease is used for lubricating these pumps, it will melt and mix with the cooling water and cause considerable radiator clogging. Inspect the pump packing each year and replace it if the packing nut is screwed nearly up. A leaking water pump causes the driving shaft to rust and corrode, and a rough shaft makes it impossible to keep the packing tight and prevent leaking. If the shaft is rough, unscrew the packing nuts and polish the shaft with fine emery cloth if it is accessible; otherwise the shaft may need to be removed for repairing.

Antifreeze solutions for cold-weather operation are as necessary for tractors as they are for automobiles. The temperature of the solution in the tractor motor cooling system should run from 180° to

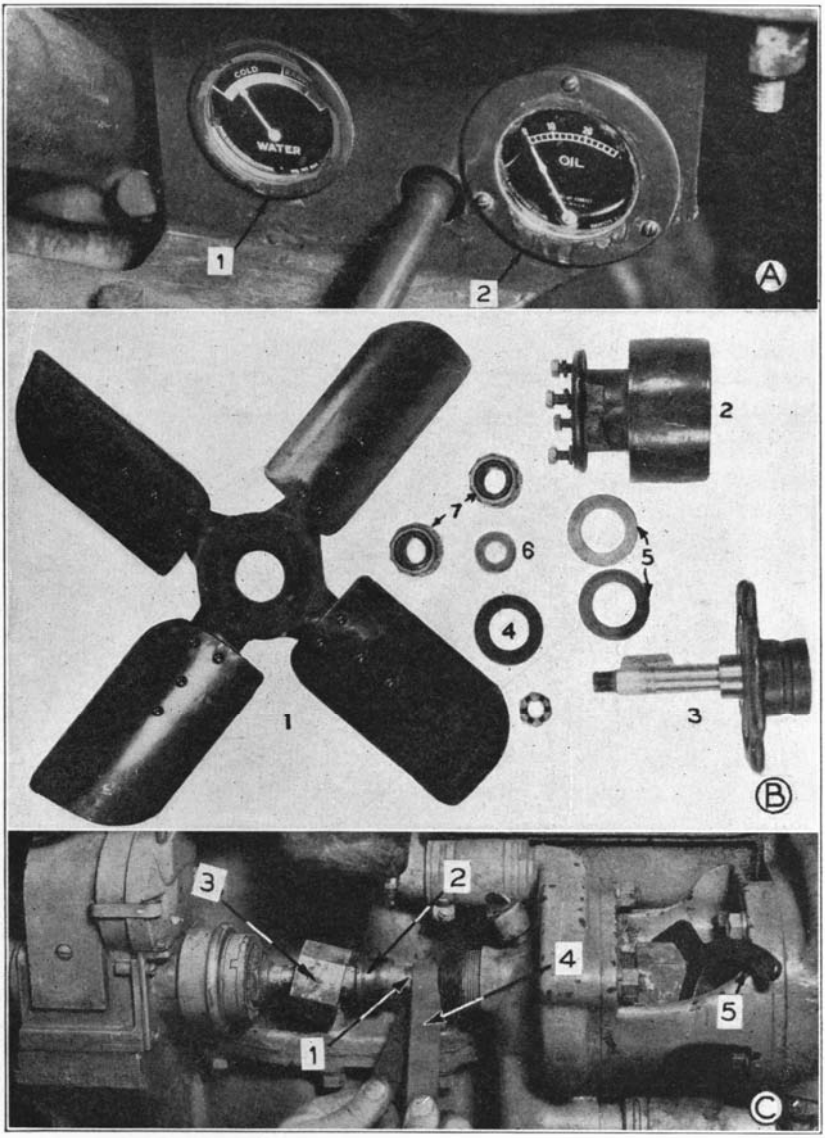

Fig. 44.—Cooling system and oil gage

A. Gages for determining: (1) water temperature, (2) oil pressure.

B. Parts of a radiator fan: (1) blades, (2) hub containing bearings, (3) shaft, (4) felt-washer oil seal, (5) metal washers, (6) shoulder washer, (7) tapered roller bearings.

C. Polishing pump shaft and replacing packing and nut: (1) pump shaft, (2) bronze collar, (3) packing nut, (4) strip of fine emery cloth, (5) wrench for tightening packing nut.

190° F.; therefore, alcohol, which evaporates at 160° F., is not satisfactory unless the motor temperature is kept below the evaporation point of alcohol. Tractors using the thermo-syphon system of water circulation (no pump being used, the water circulating only upon becoming hot) will run too hot under full load to use alcohol. Manufacturers of tractors with thermo-syphon cooling systems often recommend using just water, with a caution to adjust the radiator cover to keep the temperature above freezing. The water must be drained as soon as the tractor is stopped.

Distilled glycerine, Ethylene Glycol (Prestone), and other antifreeze mixtures of this nature are recommended by some manufacturers for their tractors. The chief objection to many of these solutions is the high cost per gallon, altho once put in the radiator they can be saved and used over again the next year. Heat does not evaporate these solutions, but extreme care must be taken to prevent leaks. It is a good plan, if possible, to keep an open can under the end of the radiator overflow pipe when expensive solutions are used so that if any of the cooling solution overflows it may be saved.

Honey, sometimes recommended as an antifreeze solution, is not satisfactory because it burns and chars, leaving a residue which clogs up the radiator.

Kerosene, distillate, fuel oils, and furnace oils have been used with success by some operators as antifreeze solutions. They have proved more successful, however, in automobiles than in tractors or trucks. For best results with these products the engine must have a good water-circulating pump and should not be equipped with thermostats. The heavier grades of fuel oils and furnace oils are sometimes used if they flow at low temperatures. Since these petroleum products do not readily conduct heat away from the cylinder walls, they may cause the engine to overheat, especially on warm days, and the operator must watch carefully for signs of overheating. They cause rapid deterioration of the rubber hose and gaskets on the engine.

Most tractor instruction books give tables or recommendations for antifreeze solutions. Do not use a solution of calcium chlorid or other alkaline solutions, as they injure the metal parts.

FRONT WHEELS AND STEERING GEAR

Front wheels work under very dusty conditions and are subject to considerable wear. Remove wheels and bearings each 700 to 1,000 hours of use and wash them carefully. The felt washer (*Fig. 45-A*) on the side of the wheel next to the frame must be in good condition to keep

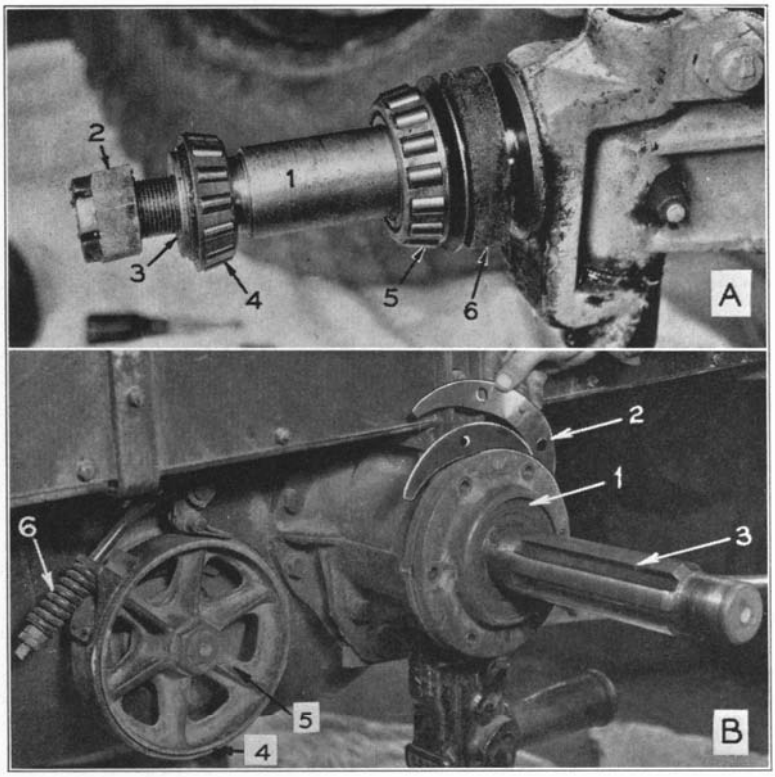

Fig. 45.—Front and rear axle parts

A. Front axle parts: (1) axle or spindle, (2) spindle nut, (3) shoulder washer, (4) front tapered roller bearing, (5) rear tapered roller bearing, (6) felt-washer grease seal.

B. Rear axle bearing adjustment and tractor brake: (1) axle bearing, (2) shims for adjusting bearing, (3) rear axle, (4) brake band and lining, (5) brake pulley, (6) brake adjustment.

the dirt out of the bearings. Since these washers stretch with use, it is desirable to put in new felt washers each year. Replace the bearings and wheel and tighten the lock nut until the wheel turns hard; then back the nut off slowly until the wheel turns freely and has a very slight amount of end-play. Be sure to place the cotter key in the nut at the end of the axle.

In lubricating the front wheels, several manufacturers and many tractor operators now do away with the front-wheel pressure-gun fittings and pack the bearings with *front-wheel bearing grease,* the same as is used for trucks and automobiles. With this method the

grease fittings are not needed, as no more grease is added to the wheels during the season. Also the inside felt washer is not soaked up with grease and loosened, allowing dirt to work into the bearing. *Get instructions from your dealer or garage mechanic on how to pack these bearings.* The wheels should be inspected once or twice during a season and tightened to prevent bearing play.

Skid bands aid greatly in turning, and they need replacing when badly worn. Proper skid bands help steer the tractor out of dead furrows and help to prevent accidents caused by skidding of the front end of the tractor.

Front axles do not need much attention, but it is desirable to make sure that the pin holding the axle to the engine or frame is securely fastened and properly lubricated.

The tie rod must be firmly fastened to each wheel spindle arm and all play removed. Adjust the tie rod so that the wheels are 1/2 to 3/4 inch closer at the front than at the back. This is called "toe-in"; it keeps the wheels working freely on their axles and makes steering easier.

The axle brace, when present, is a **V**-shaped rod extending from either side of the axle to the bottom of the crankcase or tractor frame. The connection at the axle must be kept tight and the ball-and-socket joint or other connection at the rear kept properly adjusted and lubricated.

Steering gears are usually enclosed and operate in a bath of oil. This oil must be checked and changed occasionally. If there is considerable play in the steering wheel, take it up by means of the adjustment, if one is provided, and check the play in the drag link ball-and-socket joints.

TRANSMISSION AND REAR WHEELS

If kept properly lubricated, the transmission seldom gives trouble unless some defective parts have been installed. Each gear, shaft, and bearing in the transmission is tested separately, but sometimes these parts contain flaws which cannot be detected. Defective parts are usually replaced by the manufacturer. If very extensive repairs are to be made on the transmission, it is advisable to secure the help of the dealer. Remove the cover if possible and wash out the case, using a brush and kerosene.

The transmission must be checked whenever the oil is changed to see that there are no loose shafts or bearings. *If any worn parts are found, consult the dealer immediately about their replacement.*

Since it is extremely important to keep dust out of the transmission, the gaskets and dust seals must be carefully inspected. Most transmissions have a breather provided to relieve the inside pressure caused by heat expanding the air and lubricant. If this breather is equipped with an air cleaner, see that it is properly serviced.

The transmission oil should be changed often enough to prevent the abrasives that collect in it from causing damage. These abrasives consist of dust and metal particles from inside the transmission. Held in suspension by the thick body of the oil, they circulate with the oil and cause serious wear if the oil is not changed often enough. It is a good practice to change the oil in a new tractor after the tractor has been used 400 to 700 hours, and after that to change it every 1,000 to 2,000 hours of use. Manufacturers usually recommend changing the oil each year, but since a transmission case holds 5 to 15 gallons of oil, many operators will not go to this expense.

If the tractor is operated in very cold weather, the transmission oil must be thinned down by adding 10 percent of kerosene. Then the tractor must be drained and filled with a heavier oil before it is used in warm weather (*see page 58*).

Rear wheels of steel require little attention except checking to see that all the lugs are fastened tightly, that the rivets in the spokes are holding properly, and that the bolts fastening the wheel to the axle are tight.

Rubber tires on rear wheels require more attention than steel wheels. Whenever they are used it is important to keep the air pressure at the recommended figure; lowering the air pressure does not increase the traction to any extent but may cause the sides of the tires to wrinkle, thereby weakening the fabric and causing their early failure.

For best results with rubber tractor tires follow these instructions:

1. **Check air pressure each week** and see that proper pressures are maintained:
   - a. Inflate 4-ply front tires to 28 pounds.
   - b. Inflate 6-ply front tires to 36 pounds. Front tire pressure should be increased when heavy machinery is mounted on front of tractor.
   - c. Inflate rear tires, all sizes, to 12 pounds.
   - d. When plowing, increase pressure of furrow-wheel tire to 16 pounds.
   - e. When heavy rear-mounted machinery is used, inflate rear tires to 16 pounds.

2. **Inspect constantly for damage** from cuts, punctures, and loosened cleats. Any serious damage should be vulcanized at once, but small cuts can be cleaned with gasoline and filled with tire putty.

3. Prevent tire slippage by checking to see that correct weight is being used. New synthetic-rubber tractor tires tend to scuff with slippage. The extra weight needed will not materially increase the pull. Tests have shown that 1,000 pounds of weight placed on the rear axle of a rubber-tired tractor adds only about 25 pounds to the total pull needed to tow the tractor over the ground.

4. Get correct tire weight by using water and antifreeze in tires or by bolting weights on wheels, or in both these ways. *Consult instruction book for correct weight to use.* A special liquid type of pressure gage must be used with tires containing water. The gage must be rinsed after using.

5. Change rear tires from one side of the tractor to the other every two years to give them even wear (tires on unplowed land wear faster).

Rubber tires are economical where the tractor is used for 500 hours or more of farm work a year. Best results seem to be obtained with tires having the larger inside wheel diameters, altho these cannot always be used on old models. Tires give better service with lighter loads at higher speeds than with heavier loads at lower speeds. Retreading worn rear tires should greatly increase their life and should be well worth the cost.

Rear axles are supported on bearings which gradually wear and allow the transmission lubricant to work out. The play should be taken up if an adjustment is provided, and a new oil seal should be installed (*Fig. 45-B*). If adjustments are not provided for taking up the axle-bearing play, new parts should be installed eventually.

The belt pulley is usually self-lubricated if it runs with the engine; but if it can be thrown out of gear, there is usually a place provided for lubrication when the pulley is being used. The driving gears for the pulley should mesh properly. Shims are often provided for making this adjustment.

The brake on a tractor is very important (*Fig. 45-B*). There is great danger to the operator and equipment in backing up to machinery on slanting ground or sometimes on level ground if the tractor cannot be stopped from rolling. The brakes on general-purpose tractors are necessary for short turning. Many of these brakes are of the internal expanding type consisting of two shoes which are forced apart by a cam. After the brakes have become worn, the play can be taken up either by placing shims back of the plates against which the cam works, or by supplying a new cam.

To test the brakes, jack up one wheel and try turning it with the brake set. Remove the jack and repeat with the other wheel. Brake linings must be replaced if worn. Tractors equipped with rubber tires should not be operated at all without good brakes.

LUBRICATION

All manufacturers insist upon the use of high-grade oils in their tractors because they know that these oils will hold their body and lubricating qualities longer under heat and pressure than low-grade oils. Tractors require the same high-quality oils as are used in automobiles.[1] One tractor manufacturer states at the beginning of the instruction book that "lubrication is the first and most important consideration in the life of the tractor."

Quality in crankcase oils is difficult to determine, and even laboratory tests do not reveal just what will happen to an oil when used in the crankcase of an engine. The best assurance of getting high-grade oil is to purchase the better grades manufactured by dependable companies with a national reputation for quality products. Along with high quality it is essential that the body (viscosity) of the oil be what is recommended for the engine.

High-quality oils are stable and well refined. All the impurities have been removed that it is possible to take out; they have good color, low carbon content, low cold test, and stand up under heat and pressure.

Low-grade oils are made to meet competition and are seldom economical altho they may be lower in price. They are usually unstable, which means that they thin out under heat, cause corrosion of valves and piston rings, and give off carbon, sulfur, gum, and tarry substances, which foul the motor parts and fail to provide a protective oil film between moving parts. They may also contain quantities of wax, which causes the oil to become stiff in cold weather.

Do oils wear out? is a question that is often asked. Oils of high quality, being very stable and well refined, do not wear out. They become contaminated, however, with dirt, carbon, and metal particles from the engine, and become diluted with the fuel working past the piston. Oil in this condition must be drained in order to get rid of

[1]**Requests for the testing of oils** are received from tractor owners each year. These tests, which are made in the applied chemical testing laboratory of the University of Illinois, cover the physical and chemical properties of the oil, but do not give information about the service the oil will give in a tractor or automobile.

The charge made for testing a sample of oil is five dollars, and one quart of oil is required for the test. All communications about testing oils should be directed to the Department of Chemistry, 105 Chemistry Building, University of Illinois, Urbana.

If the person requesting the test has not had sufficient training to interpret the meaning of the tests, they will be of little benefit to him. The importance of selecting good oils has been emphasized, and it is strongly recommended that oils be purchased for quality rather than low cost.

the impurities. Oil of poor quality actually wears out because much of it undergoes a chemical reaction which changes it into forms not suitable for lubrication.

Oils often turn black in engines that operate with too high a temperature. In many instances when oils are subjected to continued heating in the presence of air at temperatures around 300° F. for periods of 36 hours or longer, a cracking or oxidizing action takes place which causes the oil to turn black. Continued operation of an engine at high temperatures may cause a thick, tarry, asphaltic substance to form and settle out of the oil, resulting in a thickening of the oil. This tarry material, when mixed with water and other foreign substances in the crankcase, readily forms a sludge which may clog the screen of the oil pump, causing faulty lubrication. These asphaltic sludges are not formed at ordinary crankcase oil temperatures, which may vary from 130° to 200° F. but only at a much higher temperature such as found on the underside of the piston head. Antifreeze solutions may leak into the crankcase from the cooling system and cause a very bad sludging of the oil. The lead in the gasoline working into the crankcase may cause the oil to assume a grayish cast, but does not seem to interfere with proper lubrication in any way. *(Causes for engine overheating are given on pages 47-48.)*

Heavy-duty crankcase oil is a name given a high-quality oil to which has been added certain chemical solutions, called "additives," which greatly improve its performance. These additives keep the crankcase clean, prevent oxidation or breakdown of the oil, improve the body or viscosity of the oil under wide temperature variations, and cause it to flow freely at subzero temperatures. This kind of oil is necessary for Diesel engines. Available in all SAE grades, it will be used in all types of engines when war restrictions are removed.

Re-refined crankcase oils are now being sold rather extensively and at a lower price than new oils, and many tractor operators are wondering whether these are safe to use. When a sample of re-refined oil is compared with a new oil of the same kind, the laboratory test usually runs practically the same for both oils, with the exception that the re-refined oil may have a little less carbon. Laboratory studies of re-refined oils carried on by the U. S. Bureau of Standards have not included service tests, so that information on the relative performance of new and re-refined oils is not available from this source. There are a number of oil-refining machines in use, however, and many tractor and automobile operators report that re-refined oil gives satisfactory service. Re-refining may remove some additives from the oil.

Diesel engine crankcase oils carry addition agents to prevent the formation of carbon around the piston rings and in the combustion chamber and give the oil more stability. These addition agents readily attack the special bearing metals used in some Diesel engines, causing rapid bearing failure. Most Diesel engine manufacturers publish a list of Diesel oils recommended for their engines, and the operator should select his oil from the list. Diesel engine oils should not be used in gas engines without first consulting the engine manufacturer.

Body, or viscosity, of crankcase oil is very important. The apparatus for determining viscosity is shown in Fig. 46. The SAE standards[1] for different grades of oil are given in Table 2, *page 62*. Most late models of tractors use SAE 20W or 30 oil in summer and 10W or 20W oil in winter.

Hard starting in cold weather has been largely overcome by the introduction of the light crankcase oils that flow at very low temperatures. SAE 10W and 20W are the most important of these oils. They are completely dewaxed or are so treated as to prevent the wax from congealing; consequently they do not solidify at low temperatures and cause hard engine starting. The use of these oils in a worn engine may, however, run the oil consumption somewhat higher than normal. Following are the *automobile* manufacturers' recommendations for using these oils:

Temperatures	*Use*
40° to 0° F.	SAE 20W
0° to −15° F.	SAE 10W
Below −15° F.	SAE 10W plus 10 percent of kerosene

Most *tractor* manufacturers are recommending 20W for ordinary cold-weather operation and 10W for extremely cold weather.

The SAE standards for 10W and 20W oils are based on the viscosity or body of the oil at 0° F. and do not refer to quality in any way. The low-temperature standards are as shown on the next page.

[1]To provide a standard system of comparing the body or viscosity of all oils, the Society of Automotive Engineers (SAE) developed the SAE oil numbers. These numbers, starting with 10 and running in intervals of 10 up to 70, have a definite viscosity range for each number. The oil companies stamp these numbers on the containers of their various grades of oil so that a buyer knows just what body of oil he is purchasing.

The viscosity or body of an oil is given as the number of seconds it takes for 60 cc. of it to run thru a standard opening *at a given temperature*. SAE recommendations for regular oils are based on 130° and 210° F. The light oils (SAE-W series) are tested at 0° F.

The stated viscosity of an oil has no reference to the quality of the oil.

	Seconds viscosity at 0° F.	
	Minimum	*Maximum*
SAE Oil 10W	5,000	10,000
SAE Oil 20W	10,000	40,000

These oils should not be confused with the regular SAE 10 and 20 oils, which often have a much higher viscosity (or body) at zero, causing harder engine starting and delayed oil circulation.

SAE 10W and 20W oils can be used with perfect safety in summer as well as in winter, tho they are intended primarily for winter use. Some oil refiners make only one grade of each oil and label them SAE 10W or 10 oil, and SAE 20W or 20 oil.

In engine tests the new light oils have been found to circulate more freely and penetrate to parts of the engines that heavy oils cannot reach. (Bearings do not "seize" or burn out because the oil is too thin, but rather because the oil is too heavy to penetrate to all parts of the motor.) Automobiles and tractors are being designed with much smaller bearing and piston clearances which require the use of lighter-

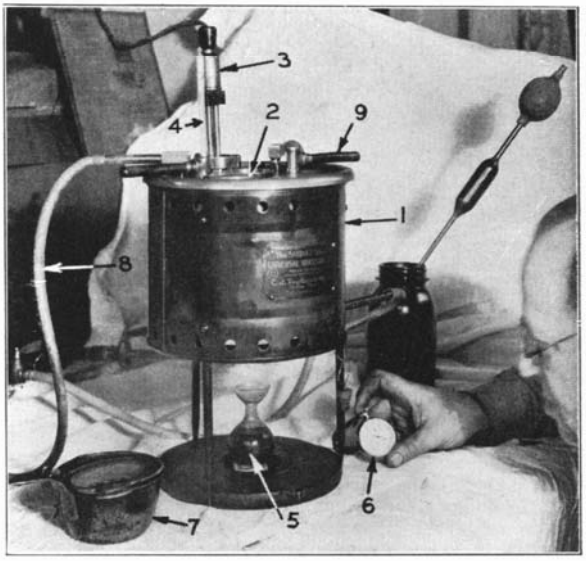

Fig. 46.—Saybolt universal viscosimeter for determining viscosity or body of oil

(1) Outside shell, (2) oil tube surrounded by a water bath, (3) electric heater for water bath, (4) thermometer, (5) beaker (60 cc.) for receiving oil from oil tube, (6) stop watch, (7) filling cup and strainer, (8) water-circulating tube for cooling water bath, (9) agitator handle for water bath.

Table 2.—SAE VISCOSITY NUMBERS FOR REGULAR GRADES OF CRANKCASE OIL

(Numbers indicate viscosity only. Other factors of oil quality or character are not considered.)

Viscosity No.	Viscosity ranges, Saybolt Universal			
	At 130° Fahrenheit		At 210° Fahrenheit	
	Minimum	Maximum	Minimum	Maximum
	seconds	*seconds*	*seconds*	*seconds*
SAE 10	90	Less than 120	...	.....
SAE 20	120	Less than 185	...	.....
SAE 30	185	Less than 255	...	.....
SAE 40	255	.....	...	Less than 80
SAE 50	...	.....	80	Less than 105
SAE 60	...	.....	105	Less than 125
SAE 70	...	.....	125	Less than 150

For *prediluted oils*, SAE viscosity numbers by which the oils are classified shall be determined by the viscosity of the undiluted oils. Wherever the SAE viscosity numbers are used on prediluted oils, the container labels should show in some suitable manner that the SAE number applies to the undiluted oil.

bodied oils. For new engines SAE 10 or 10W oil is specified for the first few days of operation.

Transmission lubricants work under entirely different conditions from crankcase oils. The method of refining these oils is therefore somewhat different. At one time the heavy black oil known as 600W was recommended for all transmissions and rear axles. Many changes in transmissions and their lubrication requirements have occurred, however, and new types of transmission lubricants have been developed which are especially suited to the present types of gears, bearings, and gear-tooth pressures. Since these tractor transmission lubricants are not required to stand up under extreme gear-tooth pressure, standard transmission lubricants of proper body are satisfactory.[1]

[1]Some trucks and automobiles require more-specialized lubricants for the transmission and rear axles. Trucks with their increasing loads, greater speed, and special types of gears develop pressures running into thousands of pounds per square inch of gear-tooth contact. Standard transmission lubricants cannot withstand these pressures, and consequently allow the gear teeth to make metal-to-metal contact, which causes rapid wear and gear failure. In order that gears working under the above conditions may be properly lubricated, special lubricants called "extreme pressure," or "EP," lubricants have been developed and can be purchased almost everywhere. Many present-day automobiles have hypoid gears in the rear axle which develop high pressure and temperature from their sliding or wiping action. A specially treated hypoid lubricant must be used for these gears.

Table 3.—SAE VISCOSITY NUMBERS FOR REGULAR GRADES OF TRANSMISSION AND REAR-AXLE LUBRICANTS

(Numbers indicate viscosity and consistency *at low temperatures only.* Other factors of quality or character are not considered.)

Viscosity No.	Viscosity range, Saybolt Universal	Consistency: must not channel in service at—
SAE 80	100,000 seconds at 0° F. (max.)	−20° F.
SAE 90	800 to 1500 seconds at 100° F.	0° F.
SAE 140	120 to 200 seconds at 210° F.	+35° F.
SAE 250	200 seconds at 210° F. (min.)	.....

Transmission and rear-axle lubricants of high quality are made from properly refined mineral oils (petroleum oils) and should not contain grit, sediment, acid, alkali, soap, resin, excessive moisture, or any substance not derived from petroleum. In order to secure transmission lubricants having a high quality and meeting the above requirements, one should purchase them from reliable companies.

Standards for the regular grades of transmission and rear-axle lubricants have been set up by the Society of Automotive Engineers and are shown in Table 3. SAE 140 transmission lubricant is usually recommended for use during temperatures above 35° F. and SAE 90 for temperatures from freezing down to zero. SAE 80 and 250 are not usually recommended except for extreme cold or heat.

Tractor manufacturers often specify that summer transmission lubricants must pour at temperatures as low as zero. This requirement allows the tractor to be used in zero weather without the necessity of thinning the lubricant.

Greases for lubricating purposes are mixtures of petroleum lubricating oils and soaps. The soap tends to harden and its chief function is to give body or stiffness to the grease so that it will stay in a bearing. Usually the more petroleum oil there is in the grease the better the lubricant. A high percentage of petroleum oil makes a soft grease.

Quality in greases is important and requires the use of the purest mineral oils, animal and vegetable fats, and alkalies. The alkalies most commonly used are calcium or lime, soda, aluminum stearate, and lead oleate. The type of alkali used in the grease determines to a large extent the general character of the product, such as hardness, water-resistance, fibrous quality, and heat-resistance. The lead-base greases are objectionable because the lead either settles out or causes excessive wear in antifriction bearings.

Used tractor and automobile crankcase oils do not make good lubricants for farm machinery, chiefly because they are too thin to stay in the bearings. The oil drained from the transmission makes a better machinery oil than that drained from the crankcase, but it should be allowed to stand long enough for the dirt and abrasives to settle.

Rust preventives for protecting the bright parts of machinery from rust can now be obtained from oil companies and implement dealers. A rust preventive is a grease or liquid to which has been added certain chemicals which seal the metal away from air and moisture, thus preventing rust. This grease applied on long tractor axles will keep them from rusting, thus making it easier to move the wheels in and out. Oils containing rust preventives are also available for filling the engine crankcase during long storage periods.

TRACTOR FUELS

Several types of fuels are available for tractors. The choice of a fuel depends upon the design of the tractor and the atmospheric temperature in which it works.

Some tractors can burn only gasoline, while others are equipped to burn both gasoline and low-grade fuels. Farmers use the low-grade fuels in order to reduce operating costs. The economy in burning low-grade fuels depends upon the design of the tractor engine and the skill of the operator. It is generally understood that engines burning low-grade fuels will require more repairs and servicing than those burning gasoline. This statement may not apply, however, to tractors designed to burn low-grade fuels if they receive the proper operating care.

Specially refined low-grade tractor fuels now have an octane rating of 40 or better. The better antiknock properties of these fuels have made it possible to raise the compression of tractor engines burning this fuel. Raising the engine compression up to around 4.7 to 1 gives these engines considerably more power with this fuel, and tractor manufacturers are taking advantage of this opportunity. These same engines will burn gasoline also to better advantage.

High-compression tractor engines burning gasoline have compression ratios around 6 to 1 or 6.5 to 1. Such ratios make it possible to get maximum power and fuel economy from leaded gasoline (*Fig. 47*). Owners who wish to change their low-compression tractors to high compression, can do so by putting in longer pistons or a cylinder head with less compression space. Old cylinder heads can be planed down.

Such engines must be equipped with a cold manifold and cold spark plugs and operated with a water temperature of 160° to 180° F.

An engine designed to burn both gasoline and low-grade fuels usually develops greater power when burning gasoline than when burning low-grade fuels, for gasoline can be more completely vaporized

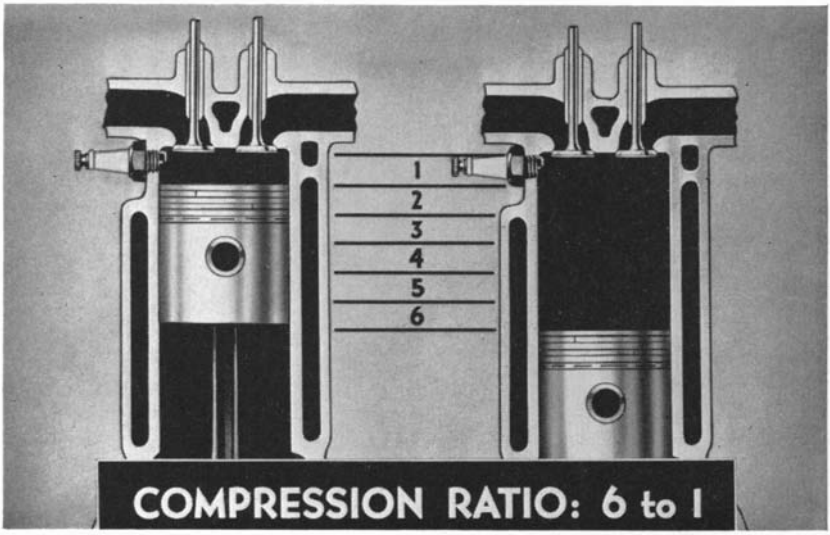

Fig. 47.—Compression ratio

If the air in a cylinder is compressed from six volumes to one volume, the compression ratio is 6 to 1. Increasing the ratio increases engine horsepower if the octane number of the fuel is high enough to prevent the engine from knocking. Compression is changed by using longer pistons or reducing the combustion space in the cylinder head.

and burned in the engine under all conditions than the low-grade fuels. Unless the difference in the cost of these two fuels is within 3 or 4 cents of each other, however, the extra power derived from burning gasoline is not likely to offset the economy of using low-grade fuels, even tho the upkeep cost of the tractor is somewhat greater when low-grade fuels are used. One exception to the above statement on cost may be the high-compression tractor engines, first introduced into Illinois in 1934, which, due to their high compression, show distinct advantages in fuel economy per acre of work done.

Burning of low-grade fuels is most successful under the engine conditions described on the next page.

1. Temperature of cooling water must be just below boiling point. A water-heat indicator to check this temperature is almost a necessity.

2. Intake manifold must be hot enough to vaporize the fuel as it enters the engine. If necessary, place a metal shield over exhaust manifold to protect it from fan blast or side winds.

3. Crankcase should be ventilated on types of engines which carry the oil supply in the crankcase.

4. Engine must operate smoothly on the fuel.

A number of low-grade tractor fuels at the present time have enough gasoline added to them to allow starting a cold engine on them. These fuels are more convenient to use because with them the engine can be operated at a somewhat cooler manifold temperature. For correct manifold heat, remove the shield, if one is used, and set the control in hot position (*Fig. 49*); if the shield is not used, set the control half way between hot and cold positions. The water temperature should be around 200° F.

Success in burning low-grade fuels depends largely upon the ability of the operator to maintain the proper engine temperatures (*Figs. 48 and 49*). Since it is difficult to maintain proper temperature in cool or cold weather, low-grade fuels cannot, as a rule, be used as

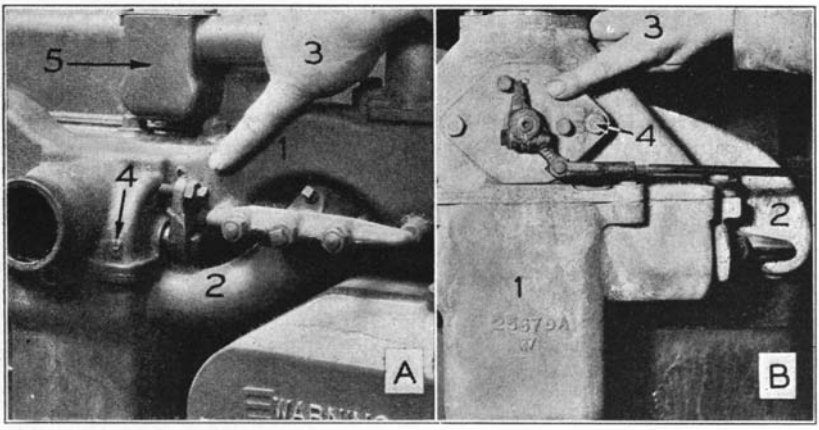

Fig. 48.—Engine manifold construction for burning gasoline or low-grade fuels

A. Hand-operated manifold heat regulator: (1) exhaust manifold, (2) intake manifold, (3) lever for changing heat set for burning gasoline, (4) position of lever for burning low-grade fuels, (5) crankcase breather.

B. Lever-operated manifold heat regulator: (1) heating chamber for fuel, (2) exhaust manifold, (3) hot manifold position for burning low-grade fuels, (4) cold manifold position for burning gasoline.

successfully in cool as in warm weather. The oil in the crankcase must be carefully watched for dilution and changed when necessary.

Kinds of low-grade fuels being used in tractors at the present time (1945) are: distillate, tractor distillate, fuel oil No. 1, furnace oil No. 1, tractor fuel, and kerosene. These fuels resemble each other

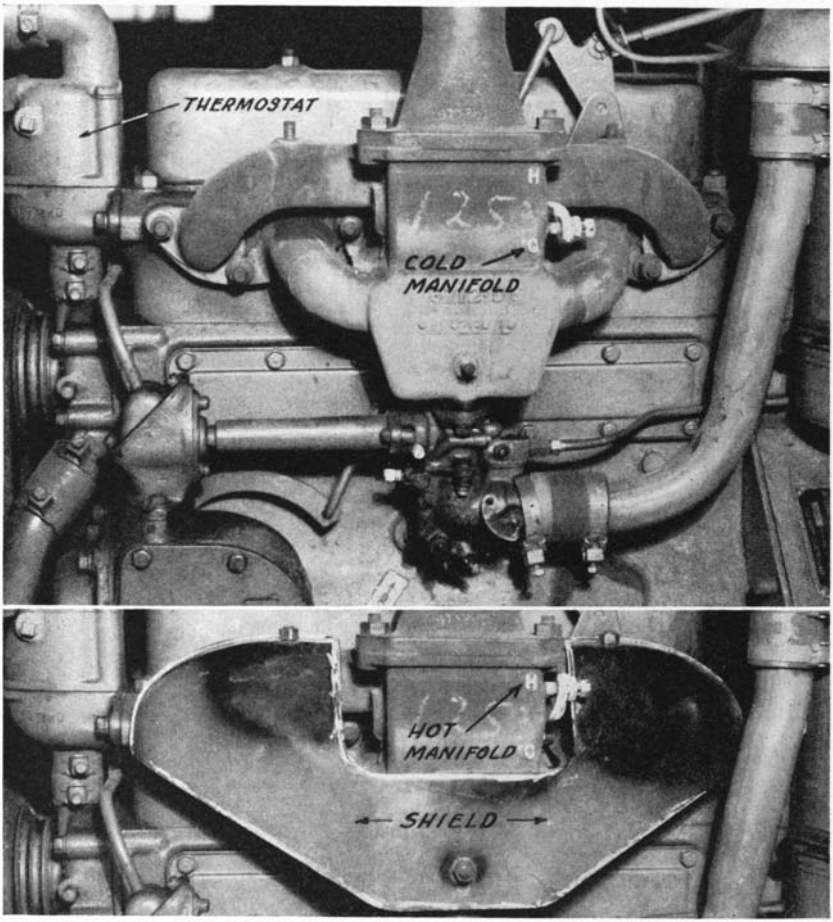

Fig. 49.—Manifold heat adjustments for two-fuel tractor

When distillate or other low-grade tractor fuel is burned in this engine, a manifold heat shield is used and the heat regulator is set on hot position, as shown in lower part of picture. When wartime "tractor fuel" is burned, the heat control is set at cold position. When gasoline is burned, the shield is removed and the heat regulator is set in cold position, as shown in the top part of the picture.

rather closely and are not much different in price. The newer low-grade tractor fuels, with an octane rating of 40 or better, are now considered to give better performance in the tractor engine than the kerosene which was formerly used. The quality of distillate or any low-grade fuel is lowered by an increase in the percentage of sulfur present, which, if excessive, makes these fuels undesirable. Sulfur from the fuel works down into the engine crankcase and, in the presence of water, forms a weak sulfuric acid which rapidly eats or corrodes the bright metal parts of the engine and causes wear and improper fitting of parts. Frequent starting, stopping, and idling of engines in cold weather increases acid formation. Therefore oil should never be left in the crankcase for as many hours of operation in cold weather as in warm weather regardless of the fuel used, unless the engine is thoroly warmed up every few days and operated in this condition for several hours.

When purchasing low-grade fuels one should make quality the first consideration. Because of the lack of standard specifications for low-grade fuels, the best assurance of securing quality is to buy from dependable oil companies with favorable reputations for products of high quality and preferably those that refine their own fuels or those that buy from companies refining their own fuels.

The saving in fuel costs made by using low-grade fuels is reported in North Dakota Extension Circular 94 as follows: "Distillate fuel costing 9 cents per gallon will save approximately 15 to 20 cents per hour in the fuel cost of the average 3-4 plow-size tractor compared to kerosene costing 15 cents per gallon." The saving in fuel cost is the only reason for using low-grade fuels.

Proper lubrication is the most important item in tractor care. On it depends the life of the engine as well as its efficient working. Neglect causes serious trouble, excessive wear, and sometimes complete breakdown.

TRACTOR OPERATION

Breaking in a new or repaired tractor requires care. Adhere strictly to the instructions given in the instruction book. Like an automobile, a tractor is a piece of fine machinery and requires some time for the parts to loosen up and adjust themselves. During the first 50 hours at least a tractor should be run at half load or less. Care during this period largely determines the life of the machine and the service it will give.

Some companies recommend using an SAE 10 or 10W oil for the first 100 hours and then changing to SAE 20 or 20W or 30.

Breaking in a tractor after it has been overhauled should be done as carefully as if the tractor were new. Use a light oil (SAE 10 or 20) and run the tractor with a light load the first day at least. Idling the tractor for three or four hours before using it in the field is strongly recommended.

Satisfactory operation in cold weather requires considerable attention. The following suggestions, which will be found also in your instruction book and in other places in this circular, are repeated here for your convenience:

1. **Change to a lighter grade of crankcase oil.**

2. **Each day loosen oil-drain plug** in bottom of oil pan enough to allow water accumulated in crankcase to drain out.

3. **Use a higher-grade fuel.**

4. **Keep fuel tank full** when tractor stands idle, in order to prevent moisture from condensing in the tank.

5. **For hard starting,** prime the motor with gasoline if possible.

6. **If temperature is below —15° F.,** use a diluted oil in oil cup of air cleaner.

7. **Keep engine warm** by using a radiator cover or installing a shutter.

8. **Drain radiator and engine** when tractor is stopped if an antifreeze solution is not used.

9. **Use a transmission oil** that will not stiffen and channel, or thin the summer oil with kerosene.

STORING THE TRACTOR

When a tractor is to be stored for any length of time, careful attention to the following suggestions is very important:

1. **Put tractor in a dry place** and jack up the wheels if on rubber. Clean the tires and paint with new tire-protective liquid to protect them against moisture and light.

2. **Clean tractor thoroly** with gasoline or kerosene and a stiff brush.

3. **Drain the crankcase,** flush with kerosene, and refill with new oil (use a rust-preventive oil if obtainable). Operate engine for 2 minutes to distribute the oil thru the engine. Do not get the engine hot.

4. **Drain the radiator and engine block** and leave the drains open.

5. **When engine has cooled,** remove spark plugs and put 1/4 pint of rust-preventive engine crankcase oil or regular crankcase oil in each cylinder. Turn engine by hand a few times to distribute the oil. Then replace the plugs.

6. **Drain fuel from tanks and carburetor** and leave drains open.

7. **Put fresh lubricant in all bearings.**

8. **Remove valve cover if possible** and cover rocker arms, springs, and valve stems with rust-preventive crankcase oil or regular crankcase oil to prevent the rusting or sticking of these parts.

9. **Stop up end of engine exhaust pipe and end of crankcase breather pipe** with rags to keep moisture from entering the valves and cylinders and the crankcase.

REMOVING TRACTOR FROM STORAGE

After a tractor has been stored for any length of time it will need careful attention before it is ready for use.

1. **Remove plugs** from exhaust and crankcase breather pipes.

2. **Drain out any rust-preventive oil** used in the crankcase for winter storage and put in the proper grade of crankcase oil. If regular oil was used for storage, remove any accumulated water from the crankcase by loosening drain plug slightly to allow drainage until the oil begins to seep out.

3. **Remove spark plugs** and pour ¼ cup of light oil thru the spark-plug openings into each cylinder. Do not replace the plugs in the engine.

4. **Remove valve cover,** thoroly lubricate the valve stems and rocker arms, and press each valve down by hand to determine whether it is working freely.

5. **Crank the engine by hand** for 25 to 50 revolutions so that the fresh oil will be distributed thruout the engine.

6. **Replace spark plugs and valve cover.**

7. **Lubricate all the working parts.**

8. **Loosen drain plugs** in bottom of transmission housing enough to allow any water that has accumulated in the housing to drain out.

9. **Fill radiator and fuel tanks.**

10. **Crank the engine** and allow it to run at 1/4 speed for 3 to 5 minutes. (CAUTION: It is best to move the tractor outside the storage room immediately to avoid the danger from exhaust gas.)

11. **If rubber tires are used,** restore the correct air pressure.

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ECONOMICAL SERVICE can be obtained from a farm tractor only when it is given proper care. To keep repairs at a minimum all parts must be thoroly checked at regular intervals by both the farmer and the dealer, and the proper oils, greases, and fuels must be used. To avoid big repair bills and high operating costs, repairs should be made just as soon as the need for them is noted.

This circular tells what to look for in checking the parts to see that they are in proper working order, and gives detailed directions for adjustment and repair.